U. S. DEPARTMENT OF THE INTERIOR

Preliminary Draft

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT
ONSHORE
OIL AND GAS LEASING
IN OREGON

Prepared by

Bureau of Land Management

Oregon State Office

May 1973

Vol. 1 of 2

LIST OF AUTHORS

Introduction ---------- B. Powers, Regional Planner, OSO (Team Chairman and Editor)

I. Background

A. Perspective ------------- D. Delavan, Geologist, OSO, B. Powers

B. Historical Perspective of Oil and Gas Leasing ------- B. Powers

C. History of Oil and Gas Leasing and Exploration in Oregon -- B. Powers

D. Policy and Authority ---------------------------------- B. Powers

E. Land Use Planning ------ R. Schroeder, Forester, OSO, B. Powers

II. Description of Oil and Gas Leasing Procedures and Operations

A. Administrative Roles - BLM and Other Federal Agencies --- B. Powers

B. Operations ----------- R. Cole, Civil Engineer, OSO, D. Delavan, W. Nelson, Mining Engineer, OSO

III. Description of the Environment

A. Geographic Location ----------------------------------- B. Powers

B. Ecological Interrelationships -------------------- R. Schroeder

C. Physiography, Geology, and Minerals ---------------- D. Delavan

D. Soils -------------------------- B. Thomas, Soil Scientist, OSO

E. Water -------------------------- E. Burroughs, Hydrologist, OSO

F. Climate and Air ---------------------------------- R. Schroeder

G. Vegetation (General) ---- C. Thomas, Forester, OSO (& co-editor)

1. Terrestrial Vegetation ------- R. Ross, Range Manager, OSO, C. Thomas

2. Aquatic Vegetation ---- A. Oakley, Fisheries Biologist, OSO

H. Animals

1. Terrestrial Wildlife ---- D. Luman, Wildlife Biologist, OSO

2. Aquatic Wildlife ---------------------------------- A. Oakley

3. Domestic Livestock ---------------------------------- R. Ross

I. Micro and Macro Organisms

1. Soil Organisms ---------------------------------- B. Thomas

2. Aquatic Organisms ---------------------------- E. Burroughs

J. Social, Economic and Land Use --- T. O'Kelly, Realty Spec., OSO

K. Aesthetics and Human Interest Values --------------- T. O'Kelly

IV. - VII (Introductions) ------------------------------------- B. Powers

A. Ecological Interrelationships -------------------- R. Schroeder

B. Physiography, Geology, and Minerals ---------------- D. Delavan

C. Soils -- B. Thomas

D. Water -- E. Burroughs

E. Climate and Air ---------------------------------- R. Schroeder

F. Vegetation (General) ---------------------------------- C. Thomas

1. Terrestrial Vegetation ----------------- R. Ross, C. Thomas

2. Aquatic Vegetation ------------------------------- A. Oakley

G. Animals

1. Terrestrial Wildlife ------------------------------- D. Luman

2. Aquatic Wildlife ---------------------------------- A. Oakley

3. Domestic Livestock ---------------------------------- R. Ross

H. Micro and Macro Organisms

1. Soil Organisms ---------------------------------- B. Thomas

2. Aquatic Organisms ---------------------------- E. Burroughs

G. Animals

1. Terrestrial Wildlife —— D. Lumes, Wildlife Biologist, [illegible]

2. Aquatic Wildlife ——————————

3. Domestic Livestock —————————————— E. Rose

I. Micro and Macro Organisms

1. Soil Organisms —————————————— C. Thomas

2. Aquatic Organisms —————————————— E. Burroughs

J. Social, Economic and Land Use —— T. O'Kelly, Realty Spec., [illegible]

K. Aesthetics and Human Interest Values —————— T. O'Kelly

IV. - VII (Introductions) —————————————— B. Powers

A. Ecological Interrelationships —————————— E. Schroeder

B. Physiography, Geology, and Minerals —————— D. Dalessio

C. Soils —————————————————————— B. Thomas

D. Water —————————————————————— E. Burroughs

E. Climate And Air ——————————————————— E. Schroeder

F. Vegetation (General) ——————————————— C. Thomas

1. Terrestrial Vegetation —————————— E. Rose, C. Thomas

2. Aquatic Vegetation —————————————— A. Oakley

G. Animals

1. Terrestrial Wildlife —————————————— D. Lumes

2. Aquatic Wildlife —————————————— A. Oakley

3. Domestic Livestock —————————————— E. Rose

H. Micro and Macro Organisms

1. Soil Organisms —————————————— E. Thomas

2. Aquatic Organisms —————————————— E. Burroughs

TABLE OF CONTENTS

The color of paper on which each of the Table of Contents parts is printed corresponds with the color on which the narrative is printed for each of the nine sections of this preliminary statement. It is hoped that this approach will be helpful to the reader in both locating subjects of interest and also in reading through the statement.

Also, all figures used are printed on white paper, and are numbered in the upper right corners.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

INTRODUCTION

This environmental impact statement has been prepared pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969. It is a programmatic statement describing, evaluating, and discussing potential environmental impacts of the oil and gas leasing program conducted by the Bureau of Land Management in Oregon. It is patterned after and correlates with the National programmatic environmental impact statement for oil and gas leasing prepared by the BLM.

Objectives

1. The objective of this statement is to provide a detailed description of the oil and gas leasing program as administered by the BLM in Oregon, and an evaluation of the anticipated environmental and human impacts.

2. Its purpose is to provide the foundation and framework for subsequent environmental analyses which will be required prior to issuance of oil and gas leases in Oregon by the BLM. It will identify factors needing close attention in such analyses as well as measures for mitigating adverse environmental impacts associated with oil and gas leasing and subsequent activities.

Scope

The action described in this statement includes all practices followed by the BLM in issuing and administering oil and gas leases in Oregon. Included are procedural aspects related to pre-lease technical

and environmental evaluations conducted by the BLM, cooperative measures with other Federal agencies such as the Geological Survey, Forest Service and the Bureau of Reclamation, and coordination with State of Oregon agencies having responsibility for oil and gas and environmental matters.

In addition to pre-lease and lease actions under the responsibility of the BLM, the scope of the statement encompasses subsequent stages of actions that could be expected to follow. These actions, within the purview of the Geological Survey, include exploratory drilling, development of a producing field (under the assumption that a commercially valuable discovery would be made), production, refining, and abandonment.

While the oil and gas leasing program is an important part of the Bureau's management mission, it represents only one of many uses that can and do take place on the public lands; some at the same time on the same land. In the context of this statement other uses, such as recreation, wildlife, watershed, timber, grazing, etc., are discussed only in terms of how they may be affected by oil and gas leasing and related activities. Impacts associated <u>with</u> wildlife, recreation, or watershed programs, all of which may be taking place simultaneous with oil and gas leasing on the same area, are not within the purview of this statement. Consequently, it does not purport to represent an environmental impact statement for a multiple use program. (See Section I E for a discussion of multiple use planning).

I. Background

A. Perspective

Oil and natural gas are important components of the Nation's energy resources. Basically they are considered relatively clean sources of energy with the major exception of petroleum products used to power automotive vehicles. Yet, domestic production of oil has developed a reputation for environmental degradation, especially considering recent events. Some of these, such as the Santa Barbara Channel offshore oil spill and the Gulf of Mexico spills and platform fires have been catastrophic in proportions. In other cases, such as the proposed development of the North Slope Alaska oil fields and the Trans-Alaska pipeline, controversy has raged around the questions of anticipated irreparable environmental damage. Smaller in scale, the recent pipeline rupture and oil spill into the San Juan River of Utah, has demonstrated the environmental risks inherent even in routine production from onshore oil fields.

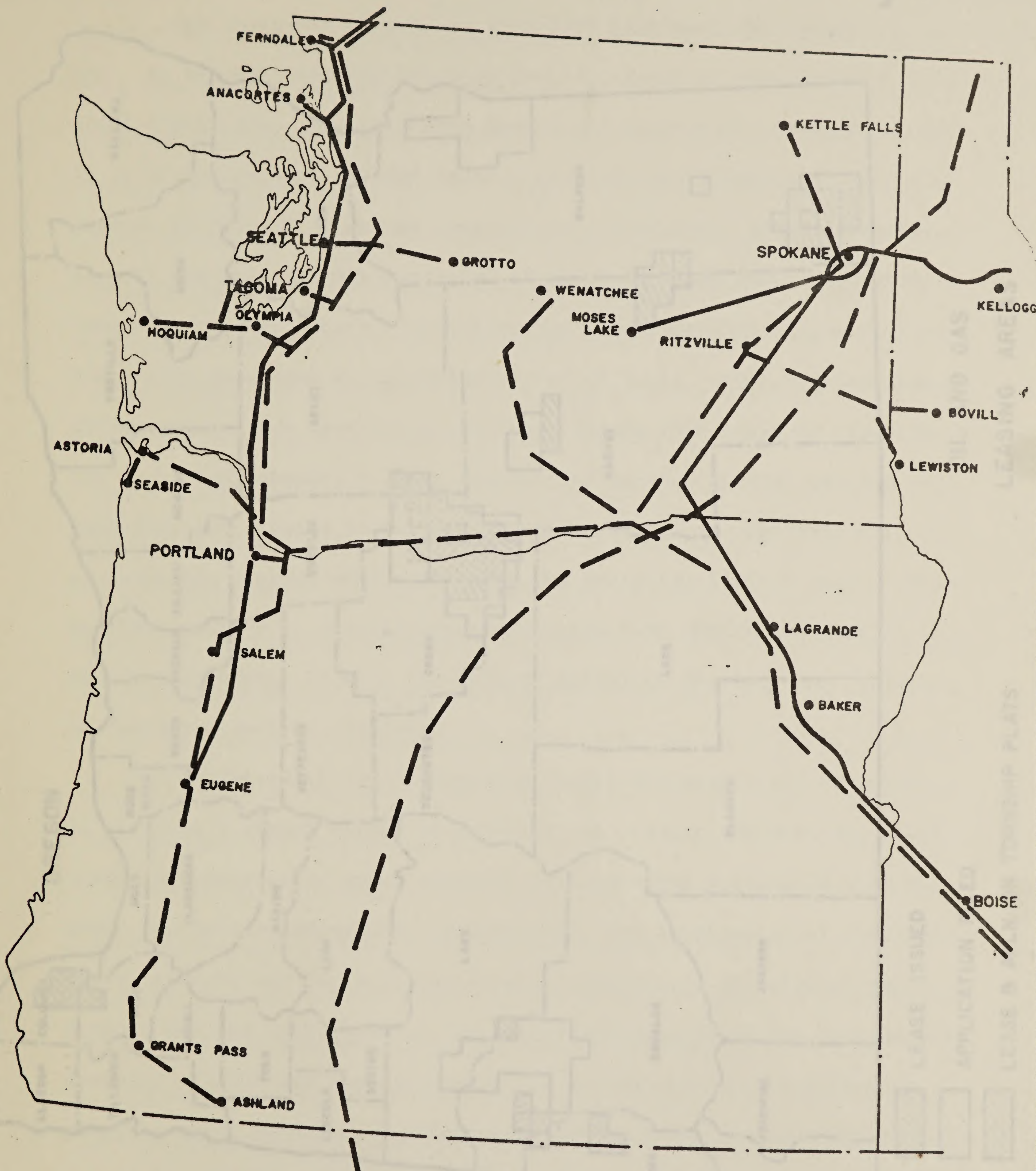
Without doubt, however, the United States is an oil and gas dependent nation and likely to remain so at least through the remainder of this century. It is also a nation that faces an energy shortage. Energy demands continue to increase well ahead of population growth while fossil fuels are finite in supply with dwindling reserves. Alternative sources of energy from renewable resources are beind developed but their growth in relative contribution to overall energy needs is slow due to technological obstacles, and environmental risks and problems are still being explored.

In 1970 crude oil supplied 45 percent of the Nation's energy needs and is expected to maintain this position through 1985. Domestic oil production, however, is projected to slip from a peak of 11½ million barrels per day in the early 1970's to 10.7 million barrels per day by 1985, despite a continuing growth in demand. To make up the deficit foreign oil import needs are projected to require an increase from the 25 percent level of 1970 to 66 percent by 1985.

The major reason for the projected slump in domestic production is a decline in domestic crude oil reserves (reserves being defined as oil recoverable under existing economic operating conditions from known sources). In 1957, crude oil reserves were estimated at 12½ times annual production. Today this ratio has slipped to 9 times annual production. The reason the 1957 reserves were not depleted by 1970 is that new oil reserves are continuously being located as the result of exploration activities. Yet the trend is developing that discoveries of new reserves are not keeping pace with depletion (BLM Preliminary Draft Environmental Impact Statement - Onshore Oil and Gas Leasing, 1972, Section I).

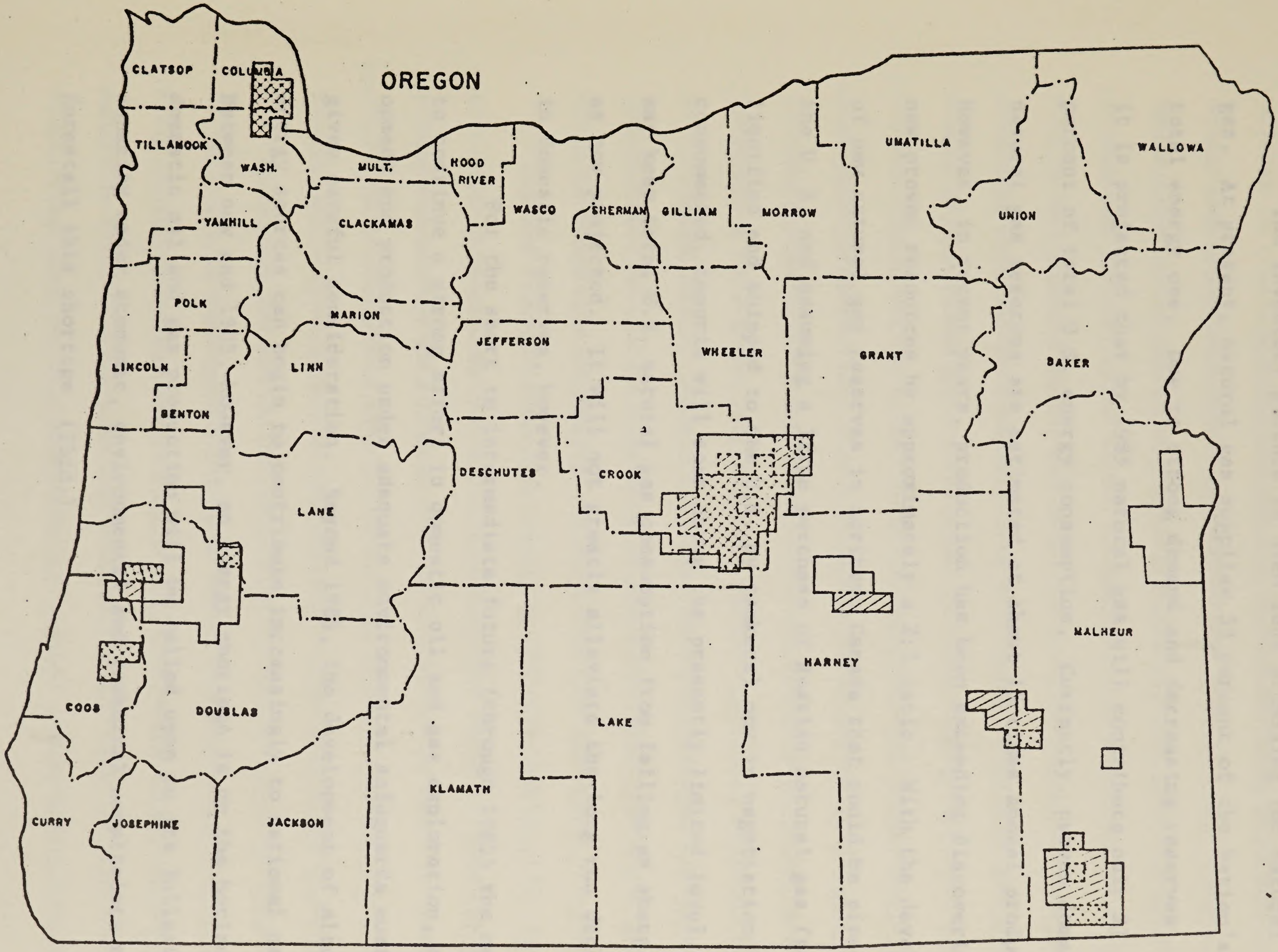
Closer to home, Oregon annually consumes 44 million barrels of crude oil and refined petroleum products, all of which are imported to the state by oceantankers and pipelines from Puget Sound refineries (See Figure 1).

Although water supplies some three precent of the nation's energy demand, within the Northwest 90 percent of total power is derived by hydrogeneration. Generating capacities of existing dams are reaching maximum capacities. Increased future energy demands in the Northwest will have to be met from sources other than hydrogeneration.



NATURAL GAS PIPELINES — — PETROLEUM PRODUCTS ——

THE NATIONAL ATLAS OF THE U.S.
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WASHINGTON, D.C., 1970
PP. 234, 236



LEASE ISSUED

APPLICATION FILED

LEASE & APLN. ON TOWNSHIP PLATS

OIL AND GAS
LEASING AREAS

Fig. 2

The inventory picture is even less promising for natural gas. At present, natural gas supplies 33 percent of the Nation's total energy use. Due to strong demand and decreasing reserves, it is projected that by 1985 natural gas will contribute only 21 percent of total U.S. energy consumption. Currently, proven domestic natural gas reserves are estimated at about 13 times annual production. However, in recent years, production has been exceeding discoveries of new proven resources by approximately a 2:1 ratio. With the development of new natural gas reserves in northern Canada that could be piped to the U. S. and assuming a large purchase of Russian natural gas (to be liquified and shipped to the U.S. by tankers) now in negotiation is consummated, imports will soar above the presently limited level. This may keep total U.S. natural gas consumption from falling as sharply as now projected. It will not greatly alleviate the long run decline in domestic reserves, however.

For the short to intermediate future (through 1985) the need to continue a strong effort in domestic oil and gas exploration, development and production under adequate environmental safeguards must be given careful consideration. Beyond 1985, the development of alternate energy sources can begin to contribute increasingly to national needs. Between now and 1985, however, an energy shortage is on the horizon and domestic oil and gas production will be called upon to its fullest capacity under economic, environmental and technical constraints to forestall this shortage (Ibid.).

B. Historical Perspective of Oil and Gas Leasing

Oil and gas leasing and subsequent production operations are increasingly coming under closer regulation and management, especially in regard to environmental safeguards. Until 1920, oil and gas were treated the same as other minerals under the General Mining Law of 1872. This law set up a miner designated system which provided that all valuable mineral deposits and the lands containing them owned by the United States were "free and open to exploration and purchase" . . . "except as otherwise expressed directly by law." Eventually, coal lands were excepted by law in 1864 and 1873, and a potash leasing act was adopted in 1917. In 1920, however, oil and gas, along with a number of other minerals received coverage under the Mineral Leasing Act of February 25, 1920. Under this act as amended (41 Stat. 437, 30 USC 181 et. seq.) and the Acquired Lands Mineral Leasing Act of August 8, 1947 (61 Stat. 913, 30 USC 351-359) provision was made that oil and gas leases on Federal lands, both public and acquired be issued by the Department of Interior (initially by the General Land Office and subsequently by local offices of the Bureau of Land Management which replaced the GLO in 1946). This same responsibility extended to oil and gas reserved to the U.S. in lands transferred out of Federal ownership.

A continuing concept in the mineral leasing laws as they apply to oil and gas has been to make a distinction between lands within a known geologic structure of a producing oil or gas field (KGS) and those outside such structures. Leases for lands within such structures are

offered at public auction. Rights to "wildcat" lands outside such structures are offered non-competitively on a first-come, first-served basis. Currently all of Oregon is outside any known oil and gas structure.

For wildcat lands, the original act provided for a system of prospecting permits. Discovery of oil or gas by a permittee entitled him to a preference right to a lease of 1/4 of the area at a 5 percent royalty rate and to a lease to the remainder of the permit area at a royalty rate of not less than 12½ percent. In 1935, the prospecting permit system was abandoned in favor of issuance of leases on a non-competitive first-come, first-served basis. Royalties were required to be not less than 12½ percent. In 1946, the royalty rate for non-competitive leases was changed to a uniform 12½ percent (BLM Preliminary Draft Environmental Statement - Onshore Oil and Gas Leasing, Section I).

Except where preference rights have been concerned, the issuance of prospecting permits and leases has been and still is discretionary with the Secretary of Interior.

Controls and management of Federal oil and gas leasing and production as now applied by the Bureau of Land Management and the U.S. Geological Survey will be discussed in detail later in this report. At this point, however, it should be noted that there are a number of Federal and State laws aimed at protecting the environment that provide controls on oil and gas operations whether under Federal lease or not. State of Oregon laws regarding oil and gas operations and environmental

quality are covered after the following discussion of Federal laws which provide significant environmental controls.

Federal Environmental Laws

The Refuse Act of 1899 (30 Stat. 1182; 33 USC 407) has been rediscovered and enforced in recent years. It requires obtaining a permit from the Army Corps of Engineers prior to disposing refuse matter in navigable waters or any tributaries thereof. Actions against violators can be initiated by private citizens and rewards granted for information leading to conviction. New regulations for the administration of this act were published in the Federal Register of April 7, 1971 (Vol. 76, No. 67, pp. 6564-6570).

The National Environmental Policy Act of 1969 (Act of January 1, 1970, PL 91-190; 83 Stat. 852) establishes a number of wide-sweeping requirements directed at the protection of the environment. NEPA does a number of things having direct or indirect impact on oil and gas operations, but specifically it:

1. Directs all Federal agencies to consider the environment in all actions to the fullest extent possible.

2. Requires an environmental impact statement "for legislation and other major Federal actions significantly affecting the quality of the human environment." The intent of this section of the act has been termed "an environmental full disclosure requirement." The Federal oil and gas leasing program is clearly a major action significantly affecting the quality of the human environment and thus subject to all requirements of NEPA.

<u>The Federal Water Pollution Control Act</u> (62 Stat. 1155; 33 USC 466 and 467) as amended by the Water Quality Improvement Act of 1970 (84 Stat. 91; Title I of Public Law 91-224), requires that prior to the issuance of a Federal Permit or lease that the applicant furnish a certification from the State Government involved that there is reasonable assurance that activities under the permit or lease will not violate applicable water quality standards. Furthermore, this legislation and its subsequent regulations (33 CFR Part 153 and 18 CFR Part 610) require that the appropriate office of the Coast Guard (for coastal waters) or Environmental Protection Agency (for inland areas) be notified of any spills of oil or hazardous substances under a penalty of up to a $10,000 fine for failure to make the required notification.

<u>The Clean Air Amendments Act of 1970</u> (42 USC 1857, et. seq. as amended by PL 91-604, December 31, 1970), provides for establishment of national, regional, state and local criteria and standards for air quality and pollutants thereto, and for enforcement of standards.

<u>The Department of Transportation Act of 1966</u> (49 USC 1651), declared among other things, that it is national policy that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites. Transportation plans and programs must contain measures to maintain or enhance the natural beauty of the lands traversed by transportation lines.

Solid Waste Disposal Act of 1965 and The Resource Recovery Act of 1970, establish grants to states and local governments for assistance in developing regional solid waste disposal plans, provides for research into waste recovery and recycling methods, and directs federal agencies having responsibility for issuing permits or licensees for disposal of solid waste (including solid wastes resulting from the extraction, processing, or utilization of minerals or fossil fuels) to insure compliance with regulations and standards promulgated under the Act.

State of Oregon Environmental Laws

Water Pollution, ORS 449.075 et. seq. These statutes prohibit discharge of wastes (including those created by the development or recovery of natural resources) into the waters of the state, or to be placed where they are likely to escape or be carried into state waters, where such discharge would reduce the quality of state waters below established water quality standards. The statute established a Department of Environmental Quality which has developed rules and regulations for minimum requirements for disposal of wastes and other matters pertaining to standards of quality for the waters of the state. The DEQ is empowered to issue permits for waste discharge.

Oregon Revised Statute 449.155 to 449.175 relate to discharge of oil and other petroleum related products into state waters. ORS 449.215 empowers the State Board of Health with general oversight and care of inland waters used as domestic water supplies.

Oregon Revised Statute 520.095 empowers the governing board of the State Department of Geology and Mineral Industries to develop rules

and regulations relating to drilling, casing and plugging of oil and gas wells to prevent pollution of fresh water, prevent blowouts, caving and seepage; to regulate "shooting" and chemical treatment of wells; and to require the disposal of salt water and oil field waste so as not to damage land or property.

Air Pollution, ORS 449.702 et seq. directs the Oregon Environmental Quality Commission to promulgate rules and regulations for sampling and monitoring air quality and control, reduce, or prevent air pollution. The DEQ is empowered to issue or deny permits for air contamination. ORS 449.785 empowers the E.Q.C. to enforce statutes relating to air pollution and to establish air quality standards for regions of the state. ORS 449.850 authorizes the establishment of regional air quality control authorities in contiguous areas consisting of two or more counties having total populations of at least 130,000.

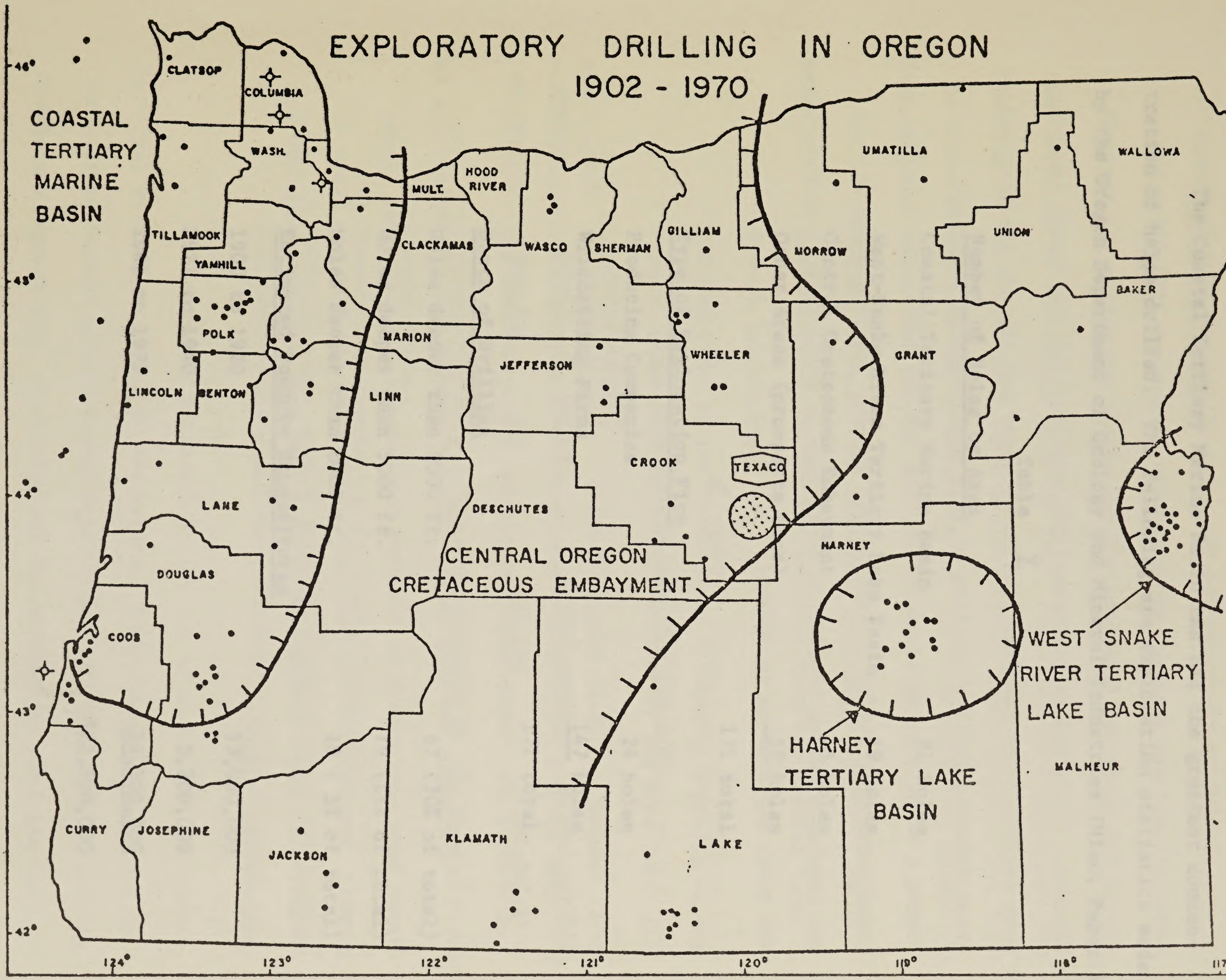
C. History of Oil and Gas Leasing and Exploration in Oregon

Since the turn of the century Oregon has undergone two periods of oil exploration, from 1900 to 1940, and from 1940 to the present. Activity during the first period was characterized by small, speculative ventures based on little geologic study. After World War II large oil companies initiated extensive geologic studies in the state and many of the companies drilled deep test holes between 1940 and 1972.

During the early 1960's efforts shifted from exploration of the inland basins of Oregon to the continental shelf bordering the State. Initial seismic studies indicated the presence of less volcanic rock in the shelf region than onshore, together with a thick section of Tertiary marine sediments. Although a number of test wells were sunk off the Oregon coast, nothing of commercial value was found, and beginning in 1970 interest again focused on the inland basins (ODGMI Miscellaneous Paper #6, 1965).

All told close to 200 exploratory wells for oil have been drilled in Oregon since 1902 (Figure 3). The last well was sunk by Texaco on a Federal lease near Paulina in Central Oregon in 1971. This hole, drilled to a depth of 8000 feet in marine sediments, was plugged and abandoned in November 1971.

More than 50 of the wells drilled both onshore and offshore have indicated shows of oil or gas. Crude oil occurs in geodes, vesicles, and crevices in the central and western part of the state, but none of the indications have proved to be commercial (ODGMI, Bul. 64, p. 218).



WELLS DRILLED IN OREGON SINCE 1902: 191
FOOTAGE: 510,000

Fig 3

The Coastal Tertiary Marine Basin has had the greatest concentration of holes drilled. The following are exploration statistics made by the Oregon Department of Geology and Mineral Industries (Misc. Paper #6):

Table I

Number of Holes by Area	
Coastal Teritary Marine Basin	81 holes
West-Snake River Tertiary Lake Basin	19 holes
Central Cretaceous Embayment	13 holes
Other Areas (prospects poor)	58 holes
	171 total
Type of Exploration Firm	
Producing Companies	24 holes
Wildcatting Firms	147 holes
	171 total
Depth of Drilling	
Holes deeper than 2000 ft.	62 (30% of total)
Holes deeper than 5000 ft.	19 (11% of total)
Holes deeper than 8000 ft.	10 (5% of total)
Estimated Onshore Expenditures	
1900 to 1920	$3,000,000
1921 to 1940	5,200,000
1941 to 1972	14,300,000
	$22,500,000

Currently there are 364,845 acres of Federal land in Oregon under oil and gas leases. Approximately 92 percent (336,782 acres) are on BLM lands and 8 percent (28,062 acres) are within the National Forests. There are an additional 204 applications for leases covering some 446,998 acres pending. Action on these and any new applications is being deferred until completion of this environmental statement. Figure 2 shows the locations of existing oil and gas leases together with areas under application for additional leases. Table II shows oil and gas leasing acres as of 1972 in comparison to total Federal surface acres and total state acres in Oregon.

Table II

Oil and Gas Leasing in Oregon 1972

Total Federal Surface (acres	Total Federal Surface Leases (acres	Pending Lease Applications Number	Pending Lease Applications Acres	Total State (acres)
32,209,302	364,845	204	446,998	61,598,720

Currently the only active drilling permits for oil exploration in Oregon have been issued to Standard Oil Company of California. These permits, one from the U.S.Geological Survey and one from the State of Oregon, will allow Standard to drill a test well near Blue Mountain in southeastern Oregon.

D. Policy and Authority

1. Policy

The minerals management program of the Bureau of Land Management is conducted in accordance with the laws, statutes, and regulations pertaining to the lands under its administration. Basic guidance set forth in these authorities and in Department of the Interior policy direct the BLM to:

- Foster, promote, and encourage the exploration for and the production of the mineral deposits from the Federal lands.
- Promote competition.
- Encourage the active development of mineral deposits on the Federal lands compatible with the use of the same lands for other purposes.
- Assure that mineral developers receive the acreage necessary for economic plant investment, development, and production.
- Encourage the maximum ultimate recovery of the mineral deposit.
- Prevent waste.
- Promote conservation of the mineral resources.
- Assure adequate minimum production and diligent development requirements and standards for leased mineral deposits.

The foregoing responsibilities are to be carried out within the full spirit and intent of the National Environmental Policy Act of 1969, other Federal environmental legislation, and supporting Executive Orders and regulations. Protection of the environment includes the

responsibilities to (1) assure that mineral exploration and production planning and conduct be done with full environmental consideration and safeguard, (2) assure prompt and adequate rehabilitation of disturbed lands and (3) assure that operations are conducted with full regard for the health and welfare of man.

2. Authority

Oil and gas leases on Federal lands, both public and acquired, are issued by the local offices of the Bureau of Land Management, under the authority of the Mineral Leasing Act of February 25, 1920, as amended (41 Stat. 437; 30 USC 181 et seq.), and the Acquired Lands Mineral Leasing Act of August 8, 1947 (61 Stat. 913; 30 USC 351-359)*. The regulations implementing the above cited acts are contained in 43 CFR, 3000 et seq., Lands Subject to Leasing, Public Domain, 43 CFR 3101. All lands subject to disposition under the acts may be leased by the Secretary of the Interior. Acquired lands may not be leased except with the consent of the agency having jurisdiction over the lands as discussed below. Land in most National Parks, Indian reservations, incorporated cities, towns, and villages, Naval Petroleum Reserves, and oil shale reserves are not subject to leasing under the above acts.

The following types of land are reserved and segregated for special treatment under terms of the regulations in 43 CFR 3101.3-3:

---

* Acquired lands are lands in Federal ownership which are not public lands. They were obtained by the Government through purchase, condemnation or gift, or by exchange for purchased, condemned or donated lands, or for timber on such lands.

Wildlife refuge lands. Such lands are those embraced in a withdrawal of public domain and acquired lands of the United States for the protection of all species of wildlife within a particular area. Sole and complete jurisdiction over such lands for wildlife conservation purposes is vested in the U.S. Fish and Wildlife Service even though such lands may be subject to prior rights for other public purposes or, by the terms of the withdrawal order, may be subject to mineral leasing.

No offers for oil and gas leases covering wildlife refuge lands will be accepted and no leases covering such lands will be issued unless it is determined that the lands are being drained, in which case, the Bureau, with the concurrence of Sport Fisheries and Wildlife, will offer the lands for lease by competitive bidding.

Game range lands. Game ranges created by a withdrawal of public lands are under the joint jurisdiction of the Bureau of Land Management and the U.S. Fish and Wildlife Service.

The Bureau of Land Management and the Fish and Wildlife Service must confer for the purpose of specifying those lands which shall not be subject to oil and gas leasing. Lands not closed to oil and gas leasing will be subject to leasing on the imposition of such stipulations agreed upon by the U.S. Fish and Wildlife Service and the Bureau of Land Management.

Coordination lands. These lands are withdrawn or acquired by the Government and made available to the states by cooperative agreements entered into between the U.S. Fish and Wildlife Service and the game commissions of the various states.

Representatives of the Bureau of Land Management and the U.S. Fish and Wildlife Service, in cooperation with the authorized members of the various state game commissions, determine which lands shall not be subject to oil and gas leasing. Lands not closed to oil and gas leasing will be subject to leasing on the imposition of such stipulations agreed upon by the State Game Commission, the U.S. Fish and Wildlife Service, and the Bureau of Land Management.

Competitive Leases (43 CFR 3120). Leases for lands in a known geologic structure of a producing oil and/or gas field are issued through competitive bidding to the qualified bidder submitting the highest acceptable bid. Leases are issued for a term of five years and for so long as oil and gas are produced in paying quantities.

Non-competitive Leases, Regular Offers (43 CFR 3110). Under the regular oil and gas leasing procedures a non-competitive lease will be issued to the first qualified person submitting an offer for the lands. Leases are issued for a primary term of ten years and for so long as oil and gas is produced in paying quantities. Since Oregon presently has no known geologic structure for producing oil and gas, all oil and gas leasing on Federal lands is currently non-competitive.

Qualifications (43 CFR 3102). Oil and gas leases may be issued to citizens of the United States, groups of such citizens, corporations organized under the laws of the United States, or any state thereof, and partnerships. Citizens of another country may hold interests

in oil and gas leases only through stock ownership in a corporation organized under the laws of the United States, or the laws of any state, provided the laws of the country grant similar privileges to U.S. citizens.

Acreage Limitations (43 CFR 3101.1-5). Competitive leases are issued for not more than 640 acres. Non-competitive leases are issued for not less than 640 acres, or for more than 2,560 acres, except in those instances where the lands applied for are surrounded by lands not available for leasing.

Total acreage in leases either competitive or non-competitive, allowed to any one person or entity in any one state except Alaska, is 246,080 acres (30 USC 184(d)). Leases included in unit or operating plans are not subject to the acreage limitations.

Simultaneous Filing Procedures (43 CFR 3112). Under the simultaneous oil and gas leasing procedures, lands in canceled or relinquished leases or in leases which terminate by operation of law for nonpayment of rental prior to the anniversary date (30 USC 188) and all lands covered by leases which expire by operation of law at the end of their primary terms are made available for releasing as provided in 43 CFR 3112.1-2, that is, on the third Monday of the month lists of such lands are posted on BLM state office bulletin boards together with notices that the lands are available for the filing of oil and gas lease offers for five days from the date of such posting. If no offers are

received for any of the parcels offered for lease, those lands become available for leasing under the regular procedures referred to above.

Rental and Royalties (43 CFR 3103). Public lands under the jurisdiction of other Federal agencies may be leased by the Secretary after consultation with the surface management agency. All leases are conditioned upon payment of an advance rental followed by royalty fees for production. Rental is payable on non-competitive oil and gas leases at the rate of 50 cents per acre per year. Upon discovery of oil and gas, royalty is payable at the rate of 12½ percent of the amount of oil and/or gas produced. Rental and royalty is payable on competitive leases at the rates prescribed in the lease terms. See 43 CFR 3103 for complete information on rentals and royalties.

Assignments (43 CFR 3106). Leases may be assigned or subleased as to all or any part of the leased acreage as to either a divided or undivided interest. All assignments must be approved by the appropriate Bureau office.

Unit Agreements (43 CFR 3105, 30 CFR 226). Lessees may commit their leaseholds to Unit Agreements for the purpose of operating under a cooperative unit development plan.* Applications to unitize are filed for approval with the Geological Survey. (See 43 CFR 3105 and 30 CFR 226).

* Unit Agreements are formed when lessees unite with each other, or with others, in collectively adopting and operating under a cooperative or unit plan of development of any oil or gas pool, field, or like area.

Extensions (43 CFR 3107). Leases may be extended under the following circumstances: (1) if actual drilling operations are being conducted on the leasehold prior to the end of the primary term, the lease will be extended for two years and for so long as oil or gas is produced in paying quantities; (2) if a lease is eliminated from a unit agreement it will continue in effect for the original term of the lease or for two years from the date it was eliminated from the agreement, whichever is longer and for so long as oil and gas is produced in paying quantities. Any lease segregated by assignment, including the retained portion, shall continue in effect for the primary term of the original lease, or for two years after the date of discovery of oil or gas in paying quantities upon any segment (43 CFR 31076-1).

Surface Management Requirements (43 CFR 3109). Lessees may be required to take all necessary measures to protect the surface of the leased lands when conducting development operations. To ensure that such measures will be taken, the Bureau requires inclusion of such stipulations in a lease as are necessary to ensure that adequate steps will be taken to protect the surface. To that end, an open ended stipulation has been developed that requires a lessee to notify the Geological Survey and the Bureau of Land Management that he plans to conduct activities on the leased lands, and to furnish maps and explanation of the nature of the activity and the anticipated extent of surface disturbance. An analysis of the environmental impact of the proposed operation is jointly made by the BLM and USGS and the lessee is advised of the

conditions, if any, to which the planned operations will be subject. The environmental analysis and special lease stipulations will be covered in more detail at the beginning of Section V, Mitigation of Environmental Impacts.

Bonds (43 CFR 3104). Appropriate bond must be furnished by the lessee prior to commencing development operations. Prior to beginning any drilling operations a bond in the amount of not less than $10,000, conditioned on compliance with all lease terms, must be posted by the lessee.

REFERENCES CITED

1. Oregon Department of Geology and Mineral Industries, Bulletin 64.
2. Steward, R.E. and Newton, V.X., Jr., "Oil and Gas Exploration in Oregon", Miscellaneous Paper No. 6, ODGMI 1965, p. 41.
3. USDI, BLM, "BLM Facts Oregon and Washington 1971 - 1972".
4. USDI, BLM Preliminary Draft Environmental Impact Statement - Onshore Oil and Gas Leasing, 1972.
5. USDI, BLM, "Public Land Statistics 1971".

II. Description of Oil and Gas Leasing Procedures and Operations

Part A of this section describes the role of the Bureau in administering onshore oil and gas leases in Oregon. This includes a description of the actions that are taken by the Bureau following receipt of oil and gas lease applications or exploration permit requests. The roles of the Geological Survey and the State of Oregon are discussed. Cooperative arrangements between other Federal agencies and the BLM are also covered briefly.

Part B of this section is a physical description of oil and gas activities that might take place on land covered by an exploration permit or oil and gas lease. The intent of this part is to give the reader unfamiliar with oil and gas exploration and development operations a better understanding of this facet of the industry. In this way, we hope, the reader will be better equipped to evaluate conclusions that are drawn in later sections of this report on the impacts that oil and gas actions might have on ecosystems, measures suggested for mitigating these impacts, and impacts that are considered unavoidable and/or irreversible despite mitigation attempts.

A. Administrative Roles - BLM and Other Governmental Agencies

1. Bureau of Land Management

The Bureau of Land Management exercises the Secretary of the Interior's discretionary authority to determine whether or not oil and gas leases are to be issued. The BLM is responsible for issuing oil and

gas leases on most Federal lands and for issuing pre-lease exploration permits on BLM administered lands.*

a. <u>Exploration Permits</u>

Exploration of Federal lands may be permitted without issuance of an oil and gas lease. Exploration permits issued for lands under BLM jurisdiction give persons rights to search for evidence of oil and gas which will require presence upon the land and which may result in damage to the lands or resources. These explorations include, but are not limited to, geophysical operations, construction of roads and trails, and cross-country transit by vehicles over Federal land (See Section II B for a description of surface exploration activities). Exploration permits <u>do not</u> authorize other use nor do they authorize <u>drilling</u> and other operations granted under oil and gas leases, nor are they issued in areas segregated from mineral activities.

The Federal agency having jurisdiction over the lands regulates oil and gas exploration permits. BLM permits are administered by the proper BLM district manager. Persons desiring to explore BLM lands must file a notice of intent to conduct oil and gas explorations with the appropriate district office prior to commencing operations. Bonds are required and the manner of exploration intended must be fully explained by the applicant.

* Federal lands are selectively available for oil and gas exploration and leasing. The Federal Mineral Leasing Laws exclude lands in incorporated cities, towns and villages, in national parks and monuments, Indian Reservations, and Naval petroleum and oil shale reserves (43 CFR 3101). Lands constituting the bed or bank or are situated within one-quarter mile of the bank of any river within an area designed under the Wild and Scenic Rivers Area are withdrawn from leasing (43 CFR 1271,1279,1280). Lands within the National Wilderness Preservation System will remain open to oil and gas leasing until December 31, 1983 (43 USC 1131,1133).

Before granting an exploration permit the local BLM district office conducts an evaluation of the proposed operation to determine (1) its effect on other programs, both Federal and State, operating in the area; (2) what precautions may be necessary to protect public health and safety; (3) the potential environmental impacts and possibilities for mitigating them; (4) what stipulations should be included in the permit, and (5) the reclamation requirements that will be required of the applicant after exploration activities cease.

After completing operations, the permittee gives notice of completion to the district manager, who inspects the area of operation and issues a notice of compliance specifying whether terms and conditions regarding reclamation of surface disturbances have been met.

b. Oil and Gas Leases

Applications for oil and gas non-competitive leases in Oregon are filed with the BLM Oregon State Office. Offers of qualified applicants are referred to the Geological Survey for determination as to whether the lands are within a known geologic structure. Currently there are no known geologic structures in Oregon.

Prior to issuance of leases the local BLM district office having jurisdiction over the proposed lease area conducts pre-lease evaluations similar to the one described for exploration permits. Evaluations already made for exploration permits covering the proposed lease area may be used to supplement pre-lease examinations.

Environmental analyses are conducted as part of the pre-lease investigations. These analyses include an evaluation of

potential environmental impacts that could be expected to occur within the lease area (for these evaluations it is expected that this environmental statement will be a major reference), an identification of areas that should be excluded from leasing, (in addition to areas already excluded in land use plans) any special stipulations that should be included in the lease, and reclamation requirements. Exhibits I and II in the Appendix at the end of Volume I of this Statement are copies of the environmental analysis format used by the Bureau and standard oil and gas lease stipulations included in all oil and gas leases. Any additional special stipulations deemed necessary for a given lease are added to the standard stipulation.

c. Lands Administered by Other Federal Agencies

Offers for oil and gas leases on lands administered by other Federal agencies are referred by the Bureau to the appropriate agency office, with requests for evaluations of the proposed leases, including whether or not they should be issued and the nature of stipulations that should be included.

2. Geological Survey

The United States Geological Survey is responsible for maintaining engineering, geologic, geophysical, economic, and other technical expertise needed to assure compliance with applicable laws, operating regulations, and the objectives of the Department of the Interior's mineral management program.

The Geological Survey prepares reports on non-competitive oil and gas lease applications referred by the Bureau (Secretarial Order No. 2948). If it is determined that the area desired for leasing is within a known

geologic structure, the finding is forwarded to the Bureau and leasing is done by competitive sale. Following competitive sales conducted by the Bureau, Geological Survey renders a post-sale recommendation regarding acceptance or rejection of the bids.

If it is determined that the desired area is not within a known geologic structure, Geological Survey prepares a report with recommendations so the Bureau may issue exploration permits or non-competitive leases. The Geological Survey also cooperates with the Bureau in the formulation of general requirements to be incorporated in leases for the protection of the surface and non-mineral resources, and for reclamation.

Geological Survey receives copies of every oil and gas lease issued by the Bureau. Once leases are issued, Geological Survey has the responsibility for administering operations conducted within lease "areas of operation" by lessees, and determines the actions to be taken by them for development, conservation, and management of mineral resources.* Geological Survey refers to the Bureau any instances of noncompliance with lease terms requiring cancellation action by the Bureau.

* The area of operation is defined as that area of the present or planned oil and gas field or geothermal resource field exploratory, development, and production operations, as presented in an approved exploration or mining plan, drilling permit, oil, gas, or geothermal field development plan, or plan for the abandonment of wells or operations. The area of operation may cover a fraction of a lease or exploration permit area, or it may cover several lease or permit areas. It encompasses the general area needed for storage piles, spoils piles, tailings ponds, on-project mill sites, flow lines, separators, surge tanks, storage tanks, on-project truck or rail-loading stations, drill pads, mud pits, workshops, compressors, generators, on-project power plants, and other such facilities used for on-project mine, oil and gas field, or geothermal resource field exploratory, development, and production operations.

Applications for drilling permits on lease areas are issued by Geological Survey. Before drilling permits are issued, however, Geological Survey and the Bureau cooperate in preparing environmental assessments of exploratory drilling plans, including provisions for surface protection and reclamation requirements.

During operations within operating areas, including exploratory drilling, development of fields, and abandonment or termination of leases, Geological Survey examines and monitors all phases of operations to insure compliance with environmental protection, conservation, and rehabilitation requirements within the operating area. Before approving oil and gas development plans, Geological Survey consults with the Bureau or other surface managing agency.

Location and "spacing" of wells and construction of facilities required for oil and gas development are governed by Geological Survey regulations (30 CFR Chapter II).

The Bureau is responsible for compliance examinations of environmental protection requirements outside the operating area and for reporting infractions to Geological Survey for discussions with, or orders to, permittees or lessees. The Bureau has the primary responsibility for approval of access roads, pipelines, utility routes and other surface uses outside the operating area, but obtains recommendations of the Geological Survey before taking final action. Orders to operators for remedial action is the responsibility of the Geological Survey.

Before approving plans for abandonment of wells or operations, the Geological Survey consults with the Bureau on the adequacy of surface use, environmental protection, and reclamation aspects of the plan.

3. State of Oregon

Laws of the State of Oregon also regulate oil and gas drilling and production under Federal land leases. These laws provide standards for minimizing waste, conserving the resource, protecting the environment and for location and spacing of wells. Detailed procedures for obtaining drilling permits, conducting operations and maintaining logs and reports have been issued in regulations of the Department of Geology and Mineral Industries (ORS Chapters 516-525, Regulations issued by Department of Geology and Mineral Industries).

Both the Bureau and Geological Survey consult and cooperate with the State of Oregon in matters relating to oil and gas exploration and leasing within the state.

B. Oil and Gas Operations

Regardless of the geographic or physiographic location, oil and gas operations and activities follow a recognized four step sequence of: exploration; development; production; and abandonment. An illustration of these four basic stages is shown in Figure 4 on the following page. Each phase is discussed as follows:

1. Exploration

Exploration activities are conducted for the purpose of locating (1) potential oil and gas producing areas and (2) specific sites for future development. Exploration for the former purpose is often identified as pre-lease exploration and exploration for the latter as post-lease. Exploration actions may also be classified as airborne, surface or subsurface:

a. Airborne Exploration.

Small single or twin engine aircraft and helicopters are used to conduct a variety of exploration surveys. Low altitude geologic reconnaissance flights at 100 to 500 feet are made to visually search for rock outcrops to give structural indications and lithologic data, both of which are studied later by a surface exploration method. High altitude flights above 3,000 feet are made to conduct photographic, sensing, geophysical magnetometer and geologic visual reconnaissance surveys.

b. Surface Exploration

There are numerous actions carried out during surface exploration. Those that require physical disturbance on the land and

represent a potential threat to the environment are frequently referred to as intensive use actions. The primary actions are seismic surveys; methods for conducting seismic surveys include (1) explosive, (2) thumper, and (3) vibrator.

In the explosives method, a truck mounted drill is used to drill holes 100 to 200 feet deep on 600 to 1400 foot spacing. The holes are loaded with 5 to 50 pounds of explosives and detonated. The same hole may be reloaded and shot numerous times to find anoptimum depth and explosive charge to return the best reflection of refraction signal possible.

The thumper and vibrator methods both use truck mounted equipment as an energy source to pound or vibrate the earth, and disturb a small surface area with no subsurface disturbance. The thumper method is used where drilling is difficult or too expensive. A weight of about 3 tons, a slab of iron, is attached by chains to a crane on a special truck. It falls several feet to the ground between guides, is picked up immediately and dropped again 10 or more feet away. The reflected signals or waves are picked up by a conventional detector spread and recorded on magnetic tape.

The vibrator method generates a continuous-wave by a signal wave generator or oscillator. The site under investigation is set into forced oscillation by a vibrator and the vibrations are recorded either at the source or at one or several points some distance away. The shakers of the vibrator are fairly heavy and cover a surface of about 10 square feet.

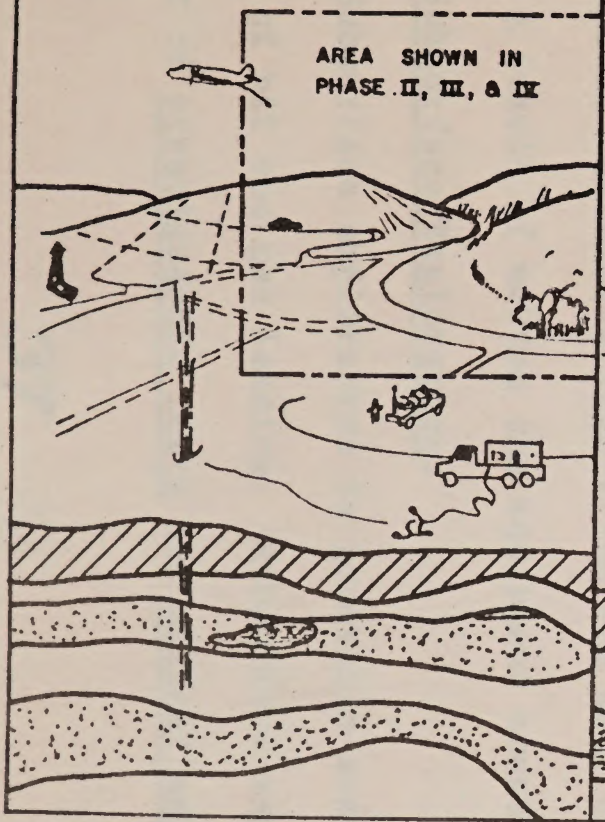
OIL AND GAS

SEQUENCE OF ACTIONS FROM EXPLORATION TO ABANDONMENT OF FIELD

PHASE I

EXPLORATION- UNKNOWN GEOLOGIC STRUCTURE

SURVEYS INVOLVE EXTENSIVE ACREAGES, WITH IMMEDIATE IMPACT ON SMALL SITES OR LINEAR AREAS; EXPLORATORY DRILLING INVOLVES FEWER SITES BUT OF LARGER SIZE.

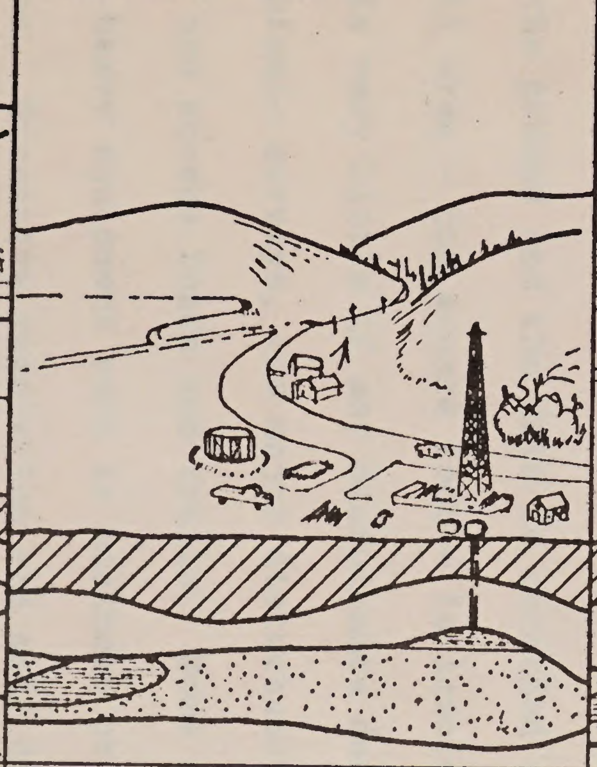


1. AIRBORNE EXPLORATION SURVEYS
2. SURFACE EXPLORATION SURVEYS
   a. GEOCHEMICAL SURVEY
   b. STRATIGRAPHIC ET AL MAPPING
   c. GEOPHYSICAL SURVEYS
      (1) EXPLOSIVE METHOD
      (2) THUMPER METHOD
      (3) VIBRATOR METHOD
      (4) GRAVITY AND OTHER METHODS
   d. GEOLOGIC SURVEYS
3. SUBSURFACE EXPLORATION DRILLING
   a. STRATIGRAPHIC TEST (LESS THAN ONE ACRE)
   b. WILDCAT WELL (3-40 ACRES)

PHASE II

DEVELOPMENT- KNOWN GEOLOGIC STRUCTURE (KGS)

DISCOVERY OF OIL AND GAS DURING THE EXPLORATION PHASE RESULTS IN DEVELOPMENT OF THE FIELD FOR PRODUCTION. THIS AS COMPARED TO EXPLORATORY PHASE, COVERS RELATIVELY MUCH SMALLER AREA BUT ON MUCH LARGER SITES.

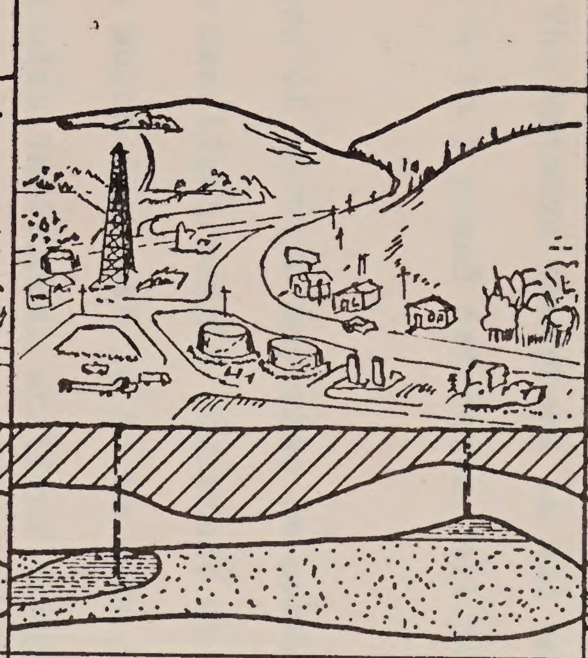


1. WELL DRILLING OF FIELD
2. ACCESS ROADS
3. PIPELINES
4. UTILITY LINES
5. SEPARATORS
6. STORAGE TANKS
7. CAMP AND BUILDINGS

PHASE III

PRODUCTION

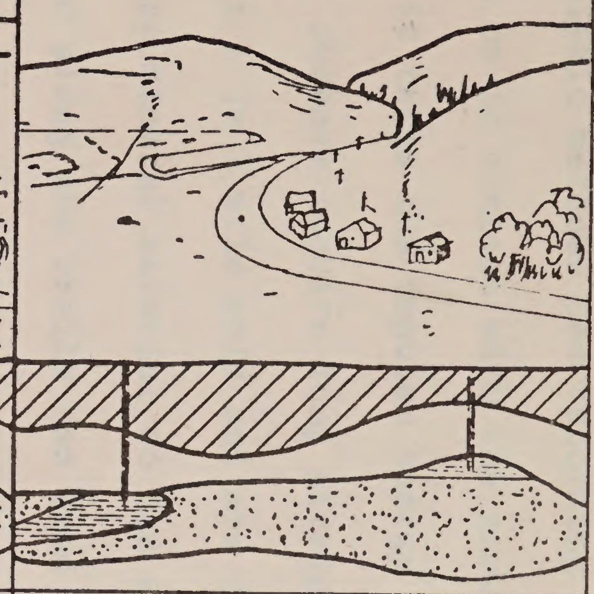
INVOLVES OPERATION AND MAINTENANCE OF FIELD, AND THE RECOVERY OF OIL AND GAS RESOURCES.



1. CONTINUED DRILLING AND DEVELOPMENT OF FIELD
2. PRESSURE MAINTENANCE SYSTEM
3. DISPOSAL OF WASTE
4. SECONDARY AND TERTIARY RECOVERY SYSTEM
5. COMMUNICATION AND PRODUCTION SYSTEMS
6. COMMUNITIES

PHASE IV

ABANDONMENT



1. REMOVE EQUIPMENT, BUILDINGS, AND FACILITIES
2. CLEAN UP FIELD
3. PLUG AND ABANDON WELLS
4. ELIMINATE HAZARDS
5. REHABILITATE FIELD
   (1) LANDSCAPE
   (2) RESEED
   (3) OTHER EROSION CONTROL
6. RECOVERY USES

FIG. 4

All three seismic methods use recording equipment or detectors which are placed on or in contact with the ground at spaced intervals to record the time it takes the impulse energy to be returned from the subsurface. Seismic surveys require long straight access trails which are laid out on a 1 to 2 mile grid and are cleared of soft vegetation cover and loose mineral material so the energy source and detectors which are spaced along the trails can send and receive as much energy as possible. The seismic equipment is all mobile and with the exception of the small ½ to 5 pound detectors, all the equipment is truck mounted.

Other types of surveys may also be conducted during exploration. Each of these use light weight equipment which is usually hand carried. The area in which the work is to be done is surveyed and a grid pattern established with individual stations flagged. Electrodes are placed on or in the ground and the data is recorded at each station successively. A small area - one square foot - is involved at each station, thus there is very little if any disturbance due to the survey itself. As in the seismic surveys, the major disturbance in an area is the establishment of new access roads and trails. Some disturbance may occur however if heavy equipment such as backhoes or bulldozers are used to obtain samples. Extensive vegetation and soil disturbance may also be caused as a result of moving the equipment cross country.

c. Subsurface Exploration.

Subsurface exploration is generally associated with the post-lease period of oil and gas leasing. Subsurface exploration activities consist of stratigraphic tests and wildcat wells.

Stratigraphic tests are shallow uncased holes usually drilled with truck mounted equipment and disturb a relatively small area.

Subsurface exploration generally requires temporary roads and trails of minimal construction to move the geophysical and drilling equipment and vehicles cross country for survey of extensive acreages to determine the geologic structure. An extensive network of very low standard roads and rails results from this operation. This network of temporary roads and trails is usually constructed with a bulldozer. The surface is cleared by removing vegetative cover and loose mineral material. Small streams and gullies are crossed by filling in the channel (constructing small dams) or by dozing out the stream banks to provide a dip, or gradual transition to enable equipment to cross. Culverts are not usually used on these temporary roads. The alignment of these roads consists of long straight lines, usually with little regard for gradient or steep slopes or rough terrain being traversed. The network of roads is usually laid out on a one (1) or two (2) mile grid.

Drilling for oil and gas in areas which are not known to be productive of oil and gas is called <u>wildcating</u>. A total of 6,922 exploratory or wildcat wells were drilled in the United States in 1971. Of these, 5834 wells were dry holes. The average depth was 7,000 feet. There were 975 active rotary drills in the United States in 1971. (I.P.A.A., the oil producing industry in your state, 1972).

Wildcate wells require large drilling rigs with many support facilities and may disturb a large surface area. The well

site normally covers an area 200 feet by 200 feet (one acre). This area can easily be doubled depending on the location and type of drilling equipment necessary. Ground conditions may require a heavy gravel base pad covering the well site to support the drill equipment and allow turn around areas for supply trucks. At the well site, the drilling rig, mud pumps, generators, pipe storage and tool house are located on the drill pad. Other facilities such as storage tanks for water and fuel and waste pits are located adjacent to the drill pad. Waste pits are built by constructing earth berms 10 feet high and 100 feet on the side, primarily to catch and store drill cuttings and fluids. Drilling equipment is then brought to the site by truck, assembled, and erected on the prepared drilling pad.

The drilling equipment usually includes the following:

<u>Power</u> - 1000 hp to 3000 hp diesel engine to supply power to rotate the drill and operate the hoists and pumps.

<u>Hoisting equipment</u> - Steel derricks that may be 100 to 250 feet high, and hoists, steel cable, pullies, and hooks for lowering and raising the drill pipe and bit.

<u>Rotating equipment</u> - The bit and drill pipe which comes in 30 foot sections of hollow steel pipe 3½ to 5 inches in diameter.

<u>Fluid circulation</u> (mud) - Essential to the drilling operation, the drill fluid performs such tasks as (1) removing drill cuttings, (2) cooling the drill bit, (3) supporting and protecting the wall of the hole, and (4) sealing the wall of the hole in porous formation. Drill fluids may contain a number of additives such as clays,

mica, cellulose, bark, cane and wood fibers, shredded rubber tires, etc. In addition a number of chemicals, many of which may be toxic or caustic, are added.

Because well drilling requires 25,000 to 30,000 gallons of water per day, for drill fluid, cleaning equipment and engine cooling, provisions for water supply must be made. Whatever water is readily available may be used, including pumping from nearby streams or lakes. If no other source is available, a water well may have to be drilled at or near the site.

Oil and gas occurring at shallow depth are usually associated with pressures at or about the equivalent of a column of salt water reaching from that depth to the surface. Gas will tend to expand when being brought to the surface and can eject some of the fluid colum from the well if not handled carefully. Drill bits, when withdrawn rapidly from a hole containing viscous mud, can exert a powerful swabbing action causing gas or other fluid to enter the bore hole unless adequate care is taken during the early stages of removing the pipe. At great depths oil, gas and salt water may be encountered unexpectedly at pressures in excess of that of the hydrostatic column.

To handle these situations a system of control equipment is installed at the well head. This equipment, commonly called a 'blow out preventer' (BOP) can close off the gap between the drill pipe and casing within 15 seconds or less, and can hold pressure up to 5000 lb/in^2 or more. Blow out preventors are also installed at various levels as the hole is deepened. Other blow out preventors, designed to close off

the entire hole when the drill pipe is out of the hole, are also installed at the well head.

Drilling is a round-the-clock operation and usually continues uninterruptedly from the moment of drilling the first foot (spudding in) until completion. Under the supervision of a drilling foreman (toolpusher), three crews, each comprising a driller and four men, work three eight-hour shifts. A mechanic attends to the engines and other specialists are called in as required.

As drilling continues, the drill cuttings are caught (sampled) at given intervals and examined by a geologist to detect any oil or gas which they may contain. If the drill cuttings give a good indication of oil or gas, the geologist may decide to test the zone where the samples came from. This can be done in a number of ways; either during the drilling or when the well is logged at completion of drilling. The most common diagnostic test is to "drill stem" test the zone. Drill stem testing allows samples of water, oil or gas to be taken directly from zones where drill cuttings gave indications of oil or gas.

At the completion of testing and drilling, the well is logged. Logging is a process whereby the electro-chemical characteristics of the rock formations penetrated by the well are measured by specialists using sophisticated equipment that is lowered to the bottom of the well on a cable. As the equipment is brought to the surface, the instruments record various diagnostic data from each formation. After thorough study of the "well logs" and drill stem test data,

geologists can usually determine whether the well has encountered hydrocarbons in sufficient quantity to warrant the expense of trying to complete the well as a producing well.

Discovery wells are nearly completed once casing has been placed in the well and cemented in place and measures taken to improve its productive capacity. Measures to improve productive capacity include perforation of the casing opposite the hydrocarbon bearing structure and treatment of the producing zone with acid.

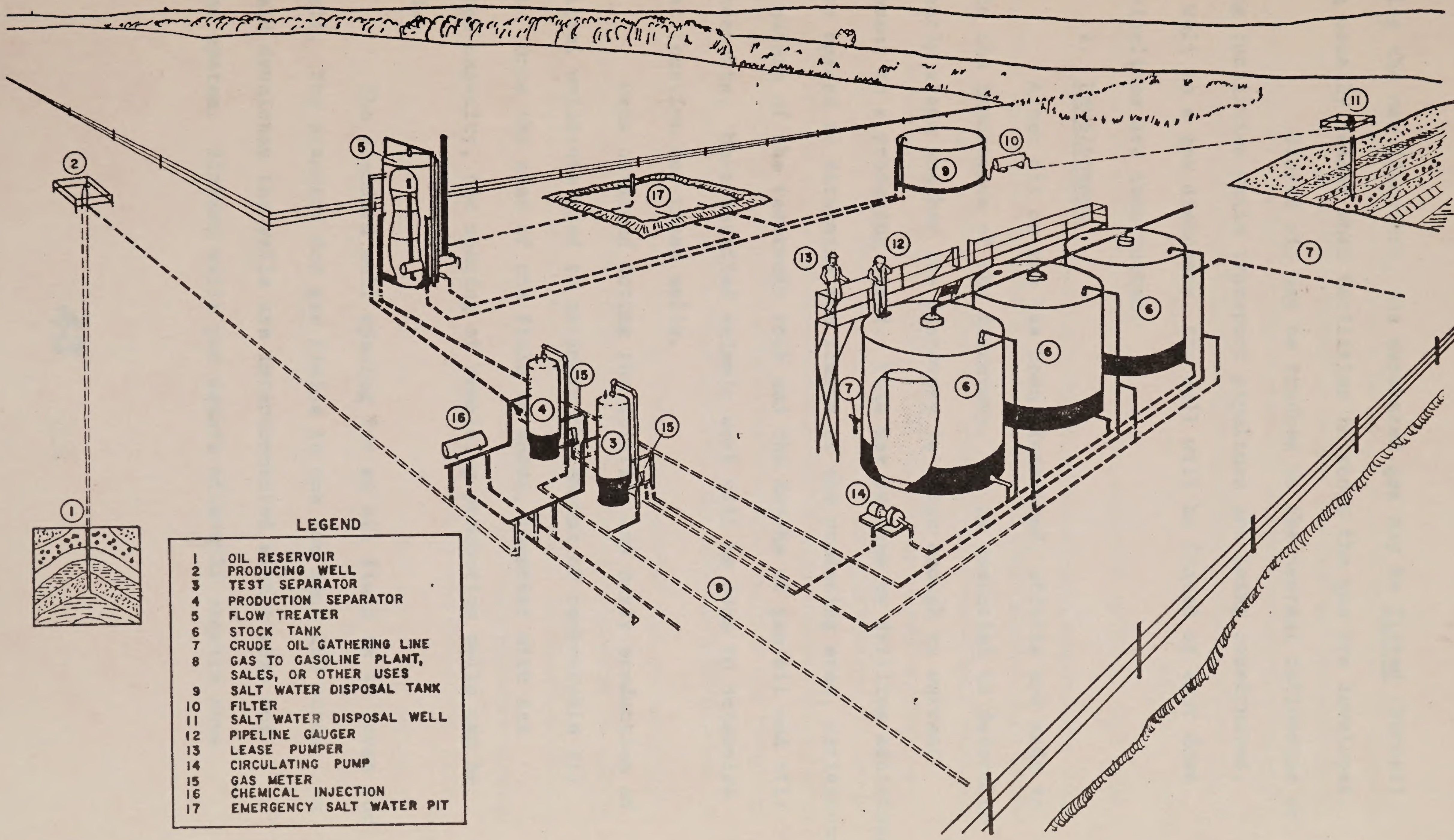
After treating the hydrocarbon or producing zone, small diameter rubing is placed inside the casing from the surface to the producing zone. The tubing is connected to the surface equipment and the well is swabbed dry to remove the water or oil which was added during treatment. If the pressure of the producing formation is sufficient to raise the oil to the surface, the well is completed as a flowing well.

A non-flowing well may be stimulated with acid or fracturing measures. If these are not successful, a pump is installed either on the surface or below the surface within the hole. When this installation is done and pumping produces oil, the well is tested for a period of time.

During the testing of a new well, additional equipment is needed at the well site. Storage tanks to hold the produced oil until pipelines can be built must be installed. If the well is a natural water or gas drive well, a separator will be necessary to remove the water or gas from the oil (See Figure 5). Depending on regulations

FLOWING OIL PRODUCTION

WELL AND FLOW LINES - SEPARATION AND STORAGE - SALT WATER DISPOSAL



LEGEND

1 OIL RESERVOIR
2 PRODUCING WELL
3 TEST SEPARATOR
4 PRODUCTION SEPARATOR
5 FLOW TREATER
6 STOCK TANK
7 CRUDE OIL GATHERING LINE
8 GAS TO GASOLINE PLANT, SALES, OR OTHER USES
9 SALT WATER DISPOSAL TANK
10 FILTER
11 SALT WATER DISPOSAL WELL
12 PIPELINE GAUGER
13 LEASE PUMPER
14 CIRCULATING PUMP
15 GAS METER
16 CHEMICAL INJECTION
17 EMERGENCY SALT WATER PIT

Fig. 5

governing the new discovery, the separated gas may be <u>flared</u> (burned). Flaring usually ceases when facilities to store the gas are developed.

Stored oil may be trucked to the nearest refineries or shipping facilities while transport pipelines are being constructed. If the well is a gas discovery, the well will be flared or shut down while pipelines are constructed.

2. Development

After oil or gas has been discovered, efforts are made to evaluate the importance of the discovery. It is essential to determine at an early stage whether the discovery is large enough to warrant development to a producing field. This may be done by drilling additional wells so spaced to determine the limits of the producing area, variations in the nature of the reservoir rock and the depths of gas/oil and oil/water contacts. More detailed seismic work will be done to determine the best location for these wells.

Data obtained during the drilling and early production of the initial wells are used to estimate the amount of recoverable oil present. Once the size of the field is known, together with its estimated capacity, the spacing of remaining production wells can be planned.

The standard well spacing for an oil field is 40 acres for each well. The standard for gas fields is one for each 160 acres. As the field developes the wells are interconnected with a road and pipeline system. Sixteen wells per square mile will require some

4 miles of road and 4 to 6 miles of a pipeline gathering system. The gathering system is a series of interconnecting flow lines which transport the produced oil and water or oil and gas to gathering stations. Gathering stations separate gas and water from the oil.

It is not unusual for several wells to be drilling at the same time, particularly where more than one lessee is operating in the field area. Major oil fields may cover several townships with each township having up to 576 wells, 200 miles of road and 200 to 300 miles of gathering system pipelines and several gathering stations.

Development of the field may require construction of additional access roads. These will usually be permanent, well designed and planned roads with large bearing capacities. Surfacing of these roads and the turn arounds may be done. Materials used in road construction vary with areas - gravel and caliche are commonly used. At swamps or marsh locations, roads and turn around areas may be paved with several layers of heavy boards to permit heavy traffic during bad weather.

3. Production

Production from each well is led through a flow line from the well to a gathering station which handles production from several wells (Figure 5). The station is equipped with separators which separate the gas and oil, and tanks in which the oil can be gauged. Water which separates freely from the crude oil is initially drained off from the gauging tanks at the gathering stations and subsequently at the main storage tanks. Water often occurs as microscopic droplets in a water-oil emulsion. These water droplets will not readily settle out and must be induced to coalesce into large drops which will freely settle out.

Hydrogen sulphide, which may occur in natural gas in large amounts is removed by alkaline absorption. It is then converted to elemental sulphur by partial combustion with air.

Disposal of water produced with the oil can be done by developing seepage sumps to allow the water to gradually re-enter the ground, putting it into nearby streams or rivers if it contains no pollutants, allowing it to evaporate into the atmosphere, or by forcefully injecting it back into the producing formation. Re-injection as in the last disposal method helps maintain pressures within the producing formation, allowing greater recovery of the oil. In some areas the water is suitable for agricultural use. Both California and Utah have made such use of oil well waste water. Generally, however, the water has too much salt in it for irrigation uses.

Pipelines used within the field may vary from 3/4 to 1 1/2 inches in diameter between the well and the gathering station. In larger fields crude oil from several wells may be collected in a gathering tank. Pipelines between the gathering tanks and treating stations may be 6 or 8 inches in diameter. Where soils are not corrosive, these pipelines may be buried. Briny water mixed with the oil can also corrode pipelines, causing them to wear out and develop leaks more rapidly. Although protective measures can be taken to prevent or minimize the possibility of leaks, they do occur. Such leaks are easier to detect and repair if the pipelines are placed on the surface rather than underground.

Production increases steadily during the development phase and then becomes steady. It willcontinue at this steady rate as long as the wells are capable of sustaining it. Primary production for 20 to 25 years is fairly common for most producing areas.

When production begins to decline, secondary recovery may be initiated. One method that has already been mentioned to stimulate secondary production is the injection of gas or water back into the formation, usually through wells that have quit producing. The remaining oil is forced through the formation to the wells that are still producing. Additional secondary recovery methods include fire flooding. Air, forced into the producing zone, combines with the gas or oil and is ignited. The heat from this fire reduces the viscosity of the oil making it easier to produce. Secondary recovery methods can double the amount of oil recoverable from a field.

During the primary production phase continued drilling and development of the field may add additional roads or extend roads and pipeline gathering systems. During this phase power and communication lines and better camp facilities are added.

a. Refining

Refining, which includes all the operations necessary to convert crude oil and natural gas into marketable oil products and chemicals, is considered part of the production phase. There are two general types of refineries; skimming and cracking, and complete.

Most refineries are skimming or cracking refineries. Such plants produce the maximum yields of high quality products, including aviation gasoline, motor and jet fuels, solvents, kerosene, diesel oils, burning oils and heavy fuel oil. Complete refineries produce many grades of lubricants and waxes with less concentration upon yields of lighter products. Paving and roofing asphalts are also produced in complete refineries.

Location of refineries depends on crude oil supply, markets, and freight rates. Permanent plants are usually located where large markets are accessible. Ideal sites for large plants usually possess transportation facilities for crude material and finished products, ample water, a suitable labor supply, soils that will support the foundation, and good drainage.

Most modern refineries are highly automated and employ between 100-200 people. Freshwater needs for refineries in California

average about 80 gallons for each barrel of product produced. Needs are expected to climb to 85 gallons by 1975 (Oil and Gas Journal, March 1966).

b. Refinery Pollution

The most common source of refinery pollution is from the products of combustion. Poorly designed and carelessly operated furnaces emit polluting materials. Evaporation from storage tanks is a source of gas vapors.

Three classes of contaminants may be encountered in refinery operations (1) gases and vapors, (2) aerosols (finely suspended particles such as smoke, fumes, mists and fog), and (3) dust (spent catalyst, fly ash, coke dust).

Gases and vapors have been broken into four classifications by the American Petroleum Institute (Bell, H.I.):

Toxic gases and vapors - Included are hydrogen sulfide, carbon monoxide, and hydrogen cyanide.

Irritant gases - Sulfur dioxide, sulfur trioxide, hydrogen flouride, hydrogen chloride, and chlorine.

Malodorous gases and vapors - Mercaptans, phenolic compounds and naphthenic acids, organic sulfides and nitrogen bases, aldehydes, amonia, and odorous compounds from other sources.

Simple asphyxiants

c. Cross-Country Pipelines

Where refineries are located at some distance from the oil fields, cross country pipelines are constructed. These pipelines

involve several phases of construction and often employ from 200-500 men during their development.

The right-of-way required varies depending on the pipe size and terrain. In wooded areas merchantable timber in the right-of-way is cut and salvaged. Other trees and brush are cut, stacked and burned. The right-of-way is graded after it has been cleared and a ditch wide enough to contain the pipe is dug. Draglines and clam shells do most of the digging in wet dirt or swampy areas. Rock ditching requires other tools and techniques, including rippers, sideboom bore hole tractors, and dynamite. Where road crossings are encountered, boring machines auger underneath the road without disturbing traffic. Pipe joints are carefully welded and inspected by X-rays for defects. The pipe is then lowered into the trench and covered. Special pipeline construction techniques, such as pipeline bridges, are used to cross rivers, railroad cuts and other obstacles where burial is not possible (Petroleum Extension Service, 1972, p. 61).

Figure 1 shows the location of existing natural gas and petroleum product pipelines in the Pacific Northwest. The natural gas pipelines bring gas from the Utah - Wyoming - Colorado area and from Canada to Washington and Oregon and on to California.

The two petroleum product pipelines in Oregon bring petroleum from refineries near Salt Lake, Utah, and from refineries in the Puget Sound area.

4. Abandonment

The abandonment phase begins during the production phase. As production declines and secondary recovery begins, the flank wells or wells on the edge of the field begin producing high volumes of water and they are usually shut in or abandoned. A portion of the abandoned wells will be stripped of their surface equipment and converted to water or gas injection wells. The remaining abandoned wells may or may not be stripped of equipment, and will be left as idle wells.

When production reaches the point where oil can no longer be recovered economically, the field is plugged and abandoned. Much of the gathering system and flow lines, if buried, will be left in place.

REFERENCES CITED

1. Bell, H.S., American Petroleum Refining, D. Van Nostrand Company, Inc. New York, p. 526.

2. The Independent Petroleum Association of America, The Oil Producing Industry in your State, 1972.

3. Oil and Gas Journal, March 28, 1966, "Water Conservation - California Style."

4. Petroleum Extension Service and Pipeline Contractors Association, A Primer of Pipeline Construction, Dallas, Texas.

5. Petroleum Extension Service, Introduction to the Oil Pipeline Industry, Dallas, Texas, 1966, pp. 84.

6. Shell International Petroleum Company Limited, The Petroleum Handbook, Shell Centre, London, 1959, p. 5.

7. Stanford Workshop on Air Pollution, Air Pollution In the San Francisco Bay Area, Stanford, California, Summer 1970.

8. U.S.D.I., Secretarial Order 2948, Division of Responsibility Between the Bureau of Land Management and the Geological Survey for Administration of the Mineral Leasing Laws - Onshore, October 6, 1972.

9. U.S.D.I., U.S.G.S., The National Atlas, Washington, D.C., 1970.

III. Description of the Environment

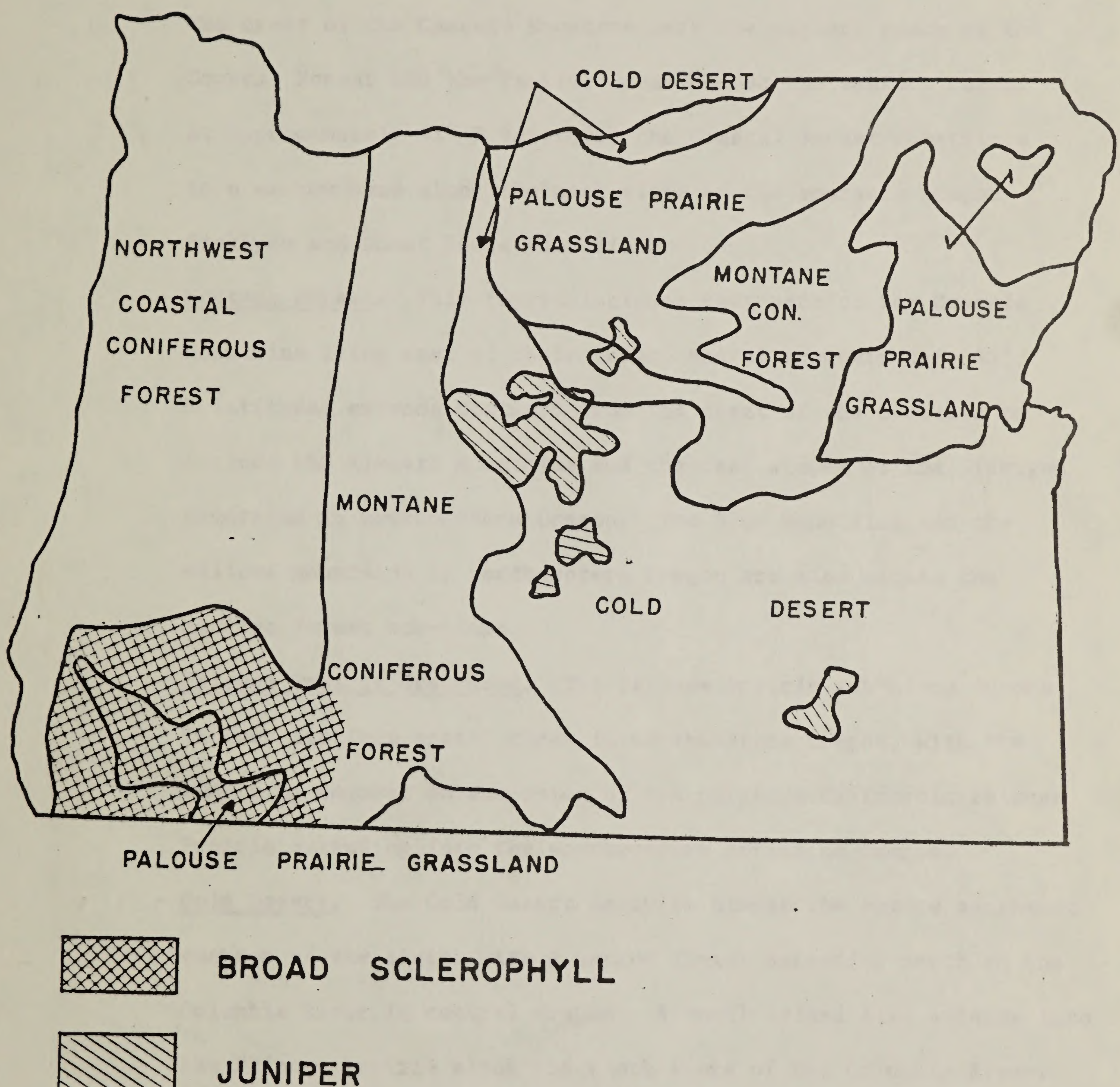
A. Geographic Location

Federal oil and gas leasing activities in Oregon encompass portions of four of the seven major biomes of the Continental United States. Biomes are major biotic communities characterized by certain plants and animals which are dominant and influent (Shelford, V. E., 1963, pg. 3). International Biome Programs have been initiated to analyze basic ecosystems and establish a scientific basis for programs to maintain or improve environmental quality (Cook, Wayne C., 1972).

The four major biomes found in part in Oregon are the Coniferous Forest, Grassland, Desert and Woodland-Bushland. To more precisely delineate ecological variations within the four broad biomes, further breakdown into sub-biomes is made. Thus the Coniferous Forest Biome in Oregon includes the Northwest Coastal Forest sub-biome and the Montane Forest sub-biome. The Grassland Biome is represented in Oregon by the Palouse Prairie Grassland sub-biome. The part of the Desert Biome occurring in Oregon is the Cold Desert sub-biome, and the Woodland-Bushland Biome includes the Juniper and Broad Sclerophyll sub-biomes.

Although precise boundaries between biomes and sub-biomes are not distinguishable in the field, they are employed in this statement in order to utilize the basic advantages of the biome approach. Upon this basis, then, data is collected, analyzed, and recommendations made on the numerous effects of the oil and gas leasing program. Organizational sub-biome boundaries which include both aquatic and terrestrial communities, are as shown in Figure 6 . Brief geographic descriptions

SUB-BIOME MAP



of the sub-biomes are as follows:

- Northwest Coastal Forest. Primarily a rain forest, it extends from the northern to the southern border of western Oregon. The crest of the Cascade Mountans mark the eastern reach of the Coastal Forest and the Pacific Ocean bounds the western reach. At approximately 43° N latitude, the Coastal Forest constricts to a narrow band along the west slope of the southern Oregon Siskiyou and Coast Range Mountains.
- Montane Forest. This forest includes that part of the Cascade Mountains lying east of their crest, and at approximately 43° N latitude, extends westward from the crest of the Cascades to include the Klamath Mountains and the east slopes of the Siskiyou Mountains in southwestern Oregon. The Blue Mountains and the Wallowa Mountains in northeastern Oregon are also within the Montane Forest sub-biome.
- Palouse Prairie Grassland. The Palouse Prairie sub-biome occurs in four distinct areas, three in northeastern Oregon, with the remaining segment an extension of the northern California Palouse Prairie extending into the southwestern corner of Oregon.
- Cold Desert. The Cold Desert occupies almost the entire southeast quarter of the state, with a narrow finger extending north to the Columbia River in central Oregon. A small island also extends into the Palouse Prairie along the south shore of the Columbia River.
- Broad Sclerophyll. The Broad Sclerophyll sub-biome occurs as biological islands within the southwestern part of the Montane

Forest and southwestern Oregon portion of the Palouse Prairie Grassland.

- Juniper. This sub-biome occurs as scattered biological islands within the Cold Desert, with isolated patches in the Montane and Palouse Prairie in eastern Oregon.

In the following parts, beginning with ecological interrelationships, the characteristics of each component of the environment are described. Characteristics of each component common to all five sub-biomes are first discussed, followed by a discussion of characteristics unique to each sub-biome, where applicable.

B. Ecological Interrelationships

All organisms share a common need to satisfy the requisites (food, shelter, moisture, respiratory gases, etc.) for continuing life and reproducing kind. A vast array of interactions serves to meet these environmental dependencies. These interactions include relationships between the individual organism and organisms of the same and of different kinds, and between the organism and its nonliving environment (Kormondy, 1969, p. 1).

1. The General Abiotic Environment (non-living)

Ecological interrelationships occur not in a vacumm but in physical-chemical settings of nonliving or abiotic environmental components. These include basic chemical elements and compounds such as water and carbon dioxide, calcium and oxygen, carbonates and phosphates, and organic compounds which are the by-products of organism activity or death. There are also such physical factors and gradients as moisture, winds, air currents, and solar radiation with its concomitants or light and heat. Within this abiotic environment, living organisms interact in a fundamentally energy-dependent fashion (ibid.).

2. The General Biotic Community

Living organisms - plants, animals and microbes - form biotic communities which occupy a complex of environments. These organisms compete for the life-sustaining light, warmth, atmospheric gases, water and nutrients provided by the abiotic environment. Each in its turn creates part of the environment affecting the others (Spurr,

1964, p. 149). These organisms are of two major kinds, autotrophic and heterotrophic. Autotrophic organisms are self-nourishing; heterotrophic organisms meet nutritional needs by feeding on other organisms (Kormondy, 1969, p. 2). More specific classification is according to function, as follows.

a. Producers are autrophic organisms which are able to manufacture food from simple inorganic substances (Odum, 1959, pp. 10, 11). In this process, radiant energy (sunlight) is used to convert carbon dioxide, water, and nutrient minerals into carbohydrates that serve as food for the producer's own growth and metabolism (Kormondy, 1969, p. 2). Producers are largely the green, chlorophyll-bearing plants; e.g., the trees of a forest, the grass of a field, the algae of a pond. Of less significance as producers are phyotosynthetic and chemosynthetic bacteria (ibid.).

b. Consumers are heterotrphic organisms, chiefly animals, which ingest organic matter (Odum, 1959, p. 11). A primary consumer (commonly an herbivore) derives its nutrition directly from plants; a secondary consumer, or carnivore, obtains it nutrition indirectly from the producer by feeding on the primary consumer (Kormondy, 1969, p. 2). Included in the consumer class are mammals, birds, reptiles, fish, worms, parasitic fungi and certain bacteria.

c. Decomposers are heterotrophic organisms which reduce, or break down, complex organic compounds, absorb some of the products of decomposition, and release the remainder in simple forms usable by the

producers (Odum, 1959, p. 11). Bacteria and fungi are the chief decomposers (ibid.), but such macro-organisms as millipedes, earthworms and mites also reduce complex organic compounds.

3. Ecosystems

A general abiotic environment and associated biotic (a general biotic community) together comprise an ecologicalsystem, or ecosystem (Kormondy, 1969, p. 1), in which living organisms and nonliving matter interact to produce an exchange of materials between the living and nonliving parts. An ecosystem, then, is a complex of vegetation, bacteria, fungi, protozoa, arthropods, various other invertebrates, vertebrates, oxygen, carbon dioxide, water, minerals, and dead organic matter (Spurr, 1964, p. 155). Such a complex is never completely in balance; an ecosystem is constantly changing diurnally, seasonally and with long-term climatic cycles (ibid., pp. 155-158).

Resisting sudden, radical changes are checks and balances, forces and counterforces, which maintain a semblance of equilibrium between organisms and environment, thus tending to stabilize the ecosystem as a whole. These factors are known as homeostatic mechanisms (Odum, 1959, pp. 7, 25-27). These include processes which regulate the storage and release of nutrients, the growth of organisms, and the production and decomposition of organic substances. As an example of the function of these mechanisms, consider the rate of photosynthesis of a whole biotic community. This may be much less variable than that of individual organisms or species within the community because, when one individual

or species slows down its rate, another may accelerate in a compensatory manner. As another example, when treated sewage is discharged into a stream at a moderate rate, the aquatic ecosystem is able to purify itself by homeostatic processes and to restore its previous quality within a few miles downstream. These mechanisms are not yet fully understood, but their important role in maintaining a natural ecological balance is known and recognized (ibid.).

While the abiotic environment controls the activities of organisms, the latter influence and control the abiotic environment in many ways. Changes in the physical and chemical nature of inert materials are constantly being effected by organisms which return new compounds and isotopes to the nonliving environment. Such organic influence can be very strong and its products significant; e.g., plants build soils which are radically different from the original substrates (Odum, 1959, p. 16).

When the environment changes as a result of actions of organisms that increase soil fertility, or because of decreased light intensity, climatic variation or any other modification, conditions may become more favorable for some organisms other than those already present. There may then be replacement of one species by another or of one biotic community by another, with more replacements following in later succession (Spurr, 1964, pp. 155-158).

Radiant energy, in the form of sunlight, is the ultimate source of energy for any ecosystem. The flow of solar energy, and two

vital cycles, are the fundamental processes which give life to an ecosystem (Kormondy, 1969, pp. 2-6, 36-40). The dynamics of these processes are described in the following paragraphs.

a. Energy Flow.

Chlorophyll, the green coloring matter of plants, converts carbon dioxide and water, in the presence of sunlight, into carbohydrates, with oxygen as a by-product, by a process known as photosynthesis. In effect, photosynthesis transforms radiant energy into chemical energy which nourishes the producer plant. During the process, the green plant also incorporates into its protoplasm a variety of inorganic elements and compounds. As the plant is utilized by herbivoes, its stored chemical energy (and nutrients) are transferred to the consumers. Likewise, there follows a transfer of energy (and nutrients) from herbivores to carnivores and eventually to the decomposers (ibid.).

This energy flow is one-way and noncyclic because, at each transfer along the food chain, energy losses occur. Within each link of the chain, beginning with the producer plant itself, some of the nutrient matter is used to build protoplasm while the stored energy in the remaining food serves as fuel for metabolism and movement. These activities convert the stored energy to heat, which is dissipated into the atmosphere and thus lost from the ecosystem. Life is sustained by continuing solar radiation with its influx of new energy (ibid.).

b. <u>The Nutrient Cycle</u>.

The nutrients produced by the green plants via photosynthesis are primarily simple carbohydrates (glucose). Two minor groups of producers, the photosynthetic bacteria and the chemosynthetic bacteria, use methods other than the process used by green plants to create carbon compounds of nutrient value. (Odum, 1959, p. 20). Further chemical changes, which occur with successive utilization along the food chain, convert the simple products of synthesis into more complex carbohydrates, proteins, fats and other nutrients.

These foods continuously circulate throughout the ecosystem from environment to producer, from producer to consumer, from consumer to decomposer, and from decomposer back to the environment, where they are potentially available for recycling. Thus, nutrients remain in the ecosystem; they are not lost in the manner of energy (Kormondy, 1969, p. 3).

As the decomposers satisfy their own needs for growth and metabolism, they concurrently perform an invaluable service to the ecosystem; this is the mineralization of organic matter. By their digestive activity, the decomposers release basic elements (nitrogen, phosphorus, potassium, calcium, etc.) to the environment for reuse by producers (ibid.). These elements are stored in the soil until extracted by the roots of vegetation, sometimes with the aid of mycorrhizal fungi (consumers) associated with the roots (Odum, 1959, p. 243) thus completing the cycle. Elemental nitrogen released from organic compounds by decomposers may be transformed into nitrate (the nitrogen derivative most

readily used by green plants) in the soil, and stored there, or it may be released into the air. Atmospheric nitrogen is continually returning to the nutrient cycle through the action of nitrogen-fixing bacteria, algae or natural electrification by lightning (ibid., pp. 31-33).

c. <u>The Hydrologic Cycle</u>.

The nutrient cycle is made possible only by the circulation of water from soil to roots of vegetation, to the atmosphere, and from the atmosphere back to the soil. Soil nutrients must be in an ionic state, in solution, to be absorbed by root systems; this requires the presence of soil moisture (Spurr, 1964, p. 100). Water also controls the rate of nutrient movement through the conductive tissue of plants, the decomposition of plant litter, and the development of the soil profile which, in turn, affects the availability of nutrients to plant roots as recycling begins (ibid., p. 84).

A major feature of the hydrologic cycle is the interchange of moisture between the earth's surface and the atmosphere via precipitation and evaporation. Significant amounts of water are used by the biota of ecosystems, and there is a substantial return of moisture to the atmosphere by transpiration from living plants, as well as by evaporation. The relative and absolute amounts of precipitation and evaporation significantly influence the structure and function of ecosystems (Kormondy, 1969, pp. 36, 37).

In its broadest sense, the hydrologic cycle involves the oceans, continents, the fresh waters and the earth's atmosphere

(Darling and Milton, 1966, p. 42). At the level of the ecosystem, the cycling of water includes precipitation from the atmosphere, runoff in the form of stream flow, and a series of intermediate processes influencing the precipitation-runoff relationship. Among these are interception of precipitation by vegetative cover, infiltration and percolation of water through the soil, evapotranspiration from soil and vegetation, surface runoff and water storage at various levels of the system. While the nature of the biotic community is determined to a large extent by the hydrologic cycle, the biotic components are, in turn, a major influence on the cycle (BLM Preliminary Draft Environmental Impact Statement - Timber Management, 1972).

4. Ecological Variations

Different ecosystems may vary widely in productivity, one index of which is the amount of vegetation produced over a given period of time (Kormondy, 1969, pp. 10, 11). The apparent mass of vegetation (the standing crop) may provide a good estimate of net productivity (Odum, 1959, p. 69). Although biomass (the total weight of the biota, including stored food) is not a consistent measure of productivity (ibid.), high rates of primary production are often associated with large biomass (Darling and Milton, 1966, p. 79).

Variations in productivity from ecosystem to ecosystem are due primarily to differences in climate and soil. These factors control energy flow, nutrient cycling and water cycling, the vital processes by which the ecosystem lives. Generally, productivity is highest in eco-

systems where abundant solar energy, ample precipitation and soils rich in nutrients promote rapid nutrient cycling and growth. The stability of the plant community is related to its productivity. Communities with low productivity are generally fragile, while highly productive communities generally recover rapidly from the impacts of heavy use or other disturbance (ibid., p. 53).

5. Sub-biomes as Ecosystems

In the concept of the ecosystem, the abiotic environment and the biota comprise an entity in which ecological kinship is demonstrated. Ecosystems are real; e.g., a pond, a field, a forest. They may also be abstract, as in the case of conceptual schemes or models patterned after real systems (Kormondy, 1969, p. 1).

Ecosystems may be conceived and studied as areas of various size. As long as a given area's major abiotic and biotic components exist and operate together with some sort of functional stability, even if only temporarily, the entity may be considered an ecosystem (Odum, 1959, p. 11). For the purpose of this statement, it is convenient to consider the Oregon sub-biomes as individual ecosystems, with ecological variations from sub-biome to sub-biome, as follows:

a. Northwest Coastal Coniferous Forest.

This is, as a whole, the most productive of Oregon sub-biomes. The "standing crop" of producers at the lower elevation forest zones is impressive and future production potentially great, if harvest-regeneration and nutrient cycles can be maintained. However,

higher elevational zones, such as subalpine and alpine, are less productive because of a shorter growing season. A large percentage of nutrients is held within the biomass (Odum, 1959, p. 393). Unlike the drier sub-biomes, understory vegetation in the lower elevational zones is well developed wherever light filters through the forest canopy, while mosses and other moisture-loving plants are abundant (ibid.).

Trees and lower levels of vegetation form a thick organic layer on the forest floor, to be broken down by bacteria and other decomposers. The ecosystem is complex; populations of producers, consumers and decomposers are relatively high. Removal of vegetation and other surface disturbance are generally followed by rapid replacement of biota through natural succession (BLM Preliminary Draft Environmental Impact Statement - Timber Management, 1972).

In general, influences of elevational differences within this sub-biome are less pronounced than in other sub-biomes due to the moderating affect of the Pacific Ocean.

b. Montane Coniferous Forest.

The distribution of biotic communities within this sub-biome is governed primarily by diverse physical conditions related to gradients in elevation and lesser oceanic influence. Mountainous areas are characterized by differential zonation of vegetation in irregular bands within various altitudinal limits, often with sudden transition from zone to zone (Odum, 1959, p. 417).

Like the Northwest Coastal, the higher elevational zones of alpine and subalpine vegetation are the least productive portions

of the sub-biome because of short growing seasons. As a whole, the sub-biome is fairly productive despite its rather severe climate. The soil contains a moderate population of small organisms but comparatively few large ones. Consequently, the breakdown or organic material proceeds more slowly than decomposition in the Northwest Coastal Coniferous Forest. Generally, low precipitation during the growing season limits the energy-nutrient-water relationships of this ecosystem (BLM Preliminary Draft Environmental Impact Statement-Timber Management, 1972).

c. Broad Sclerophyll.

Despite the xeric conditions which prevail during the summer season, this ecosystem is capable of producing a considerable mass of vegetation annually. Its existence as an intermediate community between grassland and forest is favored by the occurrence of fire (Kormondy, 1969, p. 126). Many of the species found in this plant community sprout readily from the roots after the tops are burned or cut (Weaver and Clements, 1938, pp. 531-533), and regrowth is rapid. As with chaparral communities generally, most nutrient cycling and resulting vegetative growth take place in the spring season, when precipitation and soil moisture are high (Stoddart and Smith, 1955, pp. 69-74). Its productive capacity makes this sub-biome an important source of range forage for seasonal use (ibid., p. 74).

d. Palouse Praire Grassland.

This sub-biome occurs where growing season precipitation is too low to support forest or sclerophyll ecosystems but

is higher than that which results in desert life forms (Odum, 1959, p. 397). The inherent productivity of this ecosystem is quite high; in its original form, it must have been one of the most productive range forage regions west of the Rocky Mountains (Stoddart and Smith, 1955, p. 59).

The factor limiting productivity is growing season moisture rather than nutrients (Kormondy, 1969, p. 122). Growth occurs mainly during the early spring months, when frost-free temperatures coincide with ample soil moisture. Nutrient cycling and resultant production of vegetation are rapid during the spring growing season. Grasses are mature and dry by July 1, and remain dormant during the dry summer. Fall growth occurs only in unusually favorable years (Stoddart and Smith, 1955, p. 59).

Over most of its original area, the natural vegetation of the prairie grassland has been replaced by sagebrush and annuals which have invaded as a result of overgrazing. A large portion of the ecosystem has also been converted by cultivation to the production of small grains, principally wheat (Stoddart and Smith, 1955, p. 58; Weaver and Clements, 1938, p. 528).

e. Juniper Woodland Sub-biome.

Aridity and shallow, rocky soils create growing conditions which make this ecosystem a poor producer of range forage. Probably much of this plant community never produced abundant vegetation, though in its original form it was a source of valuable early spring forage (Stoddart and Smith, 1955, p. 75). Possibly as a result of fire

control and increased grazing, the woodland seems to be extending its area by invading some adjacent portions of the Montane Coniferous Forest and Palouse Praire Grassland (ibid., p. 74).

Moisture is the initial factor in the establishment of this sub-biome, unevenly distributed rainfall accounting for its sporadic occurrence as an intermediate community between desert or grassland and montane forest (Odum, 1959, p. 411). Often juniper seems to be similar to sagebrush in its ecological requirements, the two being sometimes intermingled and sometimes alternating. In the latter situation, the sagebrush usually occurs on the moister, deeper soils and the juniper on the drier, more rocky sites (Stoddart and Smith, 1955, p. 74).

Most of the apparent biomass is in long-lived woody vegetation. This factor, and low soil moisture levels throughout most of the year result in slow nutrient cycling and vegetative growth. Deficiency of nitrogen is also believed to be a factor limiting productivity (BLM Preliminary Draft Environmental Impact Statement - Onshore Oil and Gas Leasing, 1972).

f. Cold Desert Sub-biome.

Least productive of Oregon ecosystems, the cold desert is characterized by biota which have adapted themselves to soil moisture deficiencies. Individual plants have mechanisms for reducing transpiration rates to concerve moisture; others store water in fleshy tissue. Vegetative associations display a spaced distribution in which individual plants are scattered thinly to reduce competition for soil

moisture. Desert animals (reptiles and some insects and mammals) are also adapted to aridity in various ways (Odom, 1959, pp. 402-408).

Apparently bare ground in the desert is not necessarily devoid of life. Mosses, algae and lichens may be present, and in finely divided soils may form a stabilizing crust. Blue green algae (often associated with lichens) are important as nitrogen-fixers (ibid.). Vegetative root systems, also unseen, may represent a large portion of the biomass.

Nutrient cycling in this ecosystem is inhibited by the lack of soil moisture, but little is really known of the actual mechanics of production and consumption, the cycling rates of animal and plant populations, the action of limiting factors, etc. Populations of microbial decomposers are sharply limited by dryness, which may be compensated for by large populations of rodent herbivores, but this is uncertain. At any rate, limited biotic stratification is characteristic of the desert (ibid.).

When water is no longer the limiting factor in nutrient cycling, as when the desert is irrigated, the character of the soil becomes a primary consideration. Where soil texture and nutrient content are favorable, irrigated desert land can be extremely productive because of the large energy flow provided by solar radiation. However, very large volumes of water must be used in desert irrigation. Otherwise, mineral salts may accumulate in the soil (as a result of rapid evaporation rates) and inhibit vegetative growth (ibid.).

C. Physiography, Geology, and Minerals

1. Physiography and Geology

Oregon lies within two major physiographic divisions, the Intermontane Plateaus east of the Cascades and the Pacific Mountain System west of the Cascade Range. These major divisions are further classified into provinces and sections, the sections being the smallest recognizable unit. A physiographic classification is based on those geologic processes acting on different rock types and rock structures which erode at different rates to form regions separated by recognizable boundaries. The following table is a classification of the physiographic units in Oregon. These are shown on the physiographic map on the next page, (Fig. 7).

Division	Province	Section
Pacific Mtn. System	Pacific Border Province	Oregon Coast Range Klamath Mountains Willamette Valley
	Cascade Sierra Mountains	Western & High Cascade Mtns.
Intermontane Plateaus	Columbia Plateaus	Deschutes-Umatilla Plateau, Blue Mtn. Section, High Lava Upland, Joseph Upland Snake River Canyon
	Basin and Range Province	Great Basin

a. Pacific Border Province

(1) Oregon Coast Range Physiography

The Oregon Coast Range section lies between the Klamath Mountains on the south and the Olympic Mountains on the north.

It is distinguished from the Klamath Mountains by being made up of younger and less resistant rocks than those found in the Klamath Mountains. The foot of the range is generally well marked as it descends on the east to the Willamette Valley. South of Lat. 44° it borders the Cascade Range. Between Eugene and Roseburg the range is made up of a belt of rough hills, 10 to 20 miles long, rising 500 to 1000 feet above the valleys. To the west, Tyee Mountain rises to a height of 2600 feet or about 1000 feet higher than the surrounding hills.

The range is a dissected arch of cenozoic marine sediments. The hills rise toward the south from 3000 feet to 5000 feet in elevation. The main streams flow toward the west. A coastal plain up to 3 miles wide borders much of the range and varies in altitude from 50 feet to 250 feet elevation.

(2) Oregon Coast Range Geology

The marine sedimentary rocks in this section are all tertiary in age and generally weak in nature. Volcanics are contemporaneous with or intruded into the sediments and are more resistant, forming nearly all capes and promontories on the coast and most high peaks. Structurally the range is a low anticlinorium.

(3) Klamath Mountains Physiography

The Klamath Mountains lie west of the Cascade Range between the Coast Range of Oregon and California. The mountains in this section are older and more complex than the adjacent ranges. The drainage system is transverse and shows little order as the streams have adjusted to a complex geologic structure.

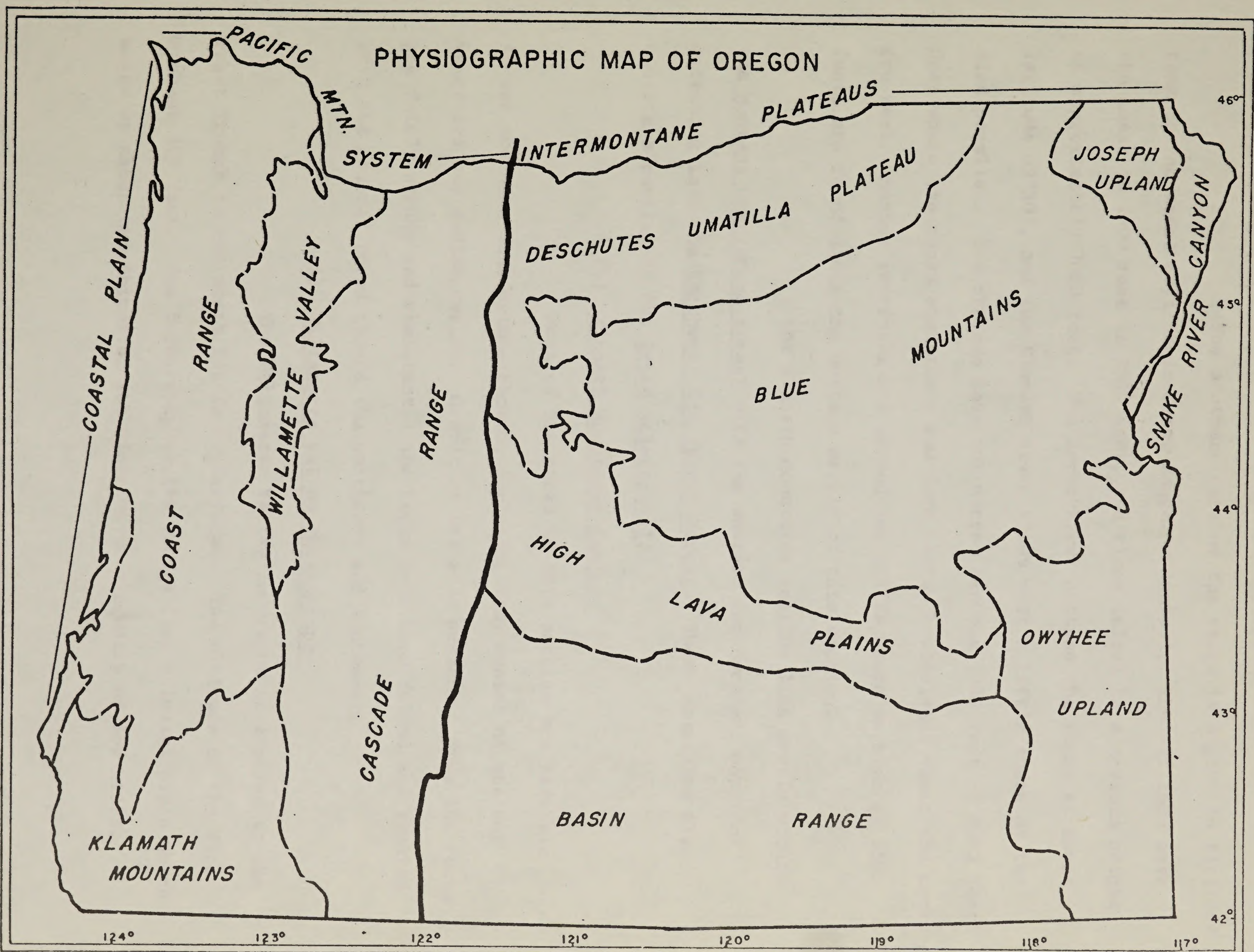

PHYSIOGRAPHIC MAP OF OREGON
PACIFIC
MTN.
SYSTEM
INTERMONTANE
PLATEAUS
COASTAL PLAIN
COAST RANGE
WILLAMETTE VALLEY
CASCADE RANGE
DESCHUTES UMATILLA PLATEAU
JOSEPH UPLAND
SNAKE RIVER CANYON
BLUE MOUNTAINS
HIGH LAVA PLAINS
OWYHEE UPLAND
BASIN RANGE
KLAMATH MOUNTAINS
46°
45°
44°
43°
42°
124°
123°
122°
121°
120°
119°
118°
117°

Fig 7

The southern part of the range is higher in altitude than the adjacent California Coast Range. Generally, the altitude near the coast is 2000 feet to 2500 feet, and rises inland to a maximum height of approximately 7000 feet. The Rogue River crosses the range at about latitude 42°30', and the Klamath River flows west a little south of the 42nd parallel. The streams have cut narrow canyons 1000 feet to 2000 feet deep where the rocks are strong and form narrow bottomlands where the rocks are weak. Marine terrances and eroded sea cliffs, some as high as 1500 feet, are found along the western margin of this section.

The Klamath Mountains section lies mostly within the Montane Coniferous Forest with the western and northern portions extending into the Northwest Coniferous Forest. These mountains also contain a portion of the Broad Sclerophyll.

(4) Klamath Mountains Geology

Most of the rocks in this section are Mesozoic in age and have been metamorphosed, including many masses of ancient volcanics and sedimentaries. Granitics are also present. Thus the rocks are fairly strong and resistant. The rocks have been folded and faulted with the general trend toward the mortheast and southwest.

(5) Willamette Valley Physiography

The Willamette Valley in Oregon is similar to the Puget Trough to the north but is unglaciated. The altitude of the floor is about 500 feet. The topography varies from a flat alluvial plain which makes up about two-thirds of the district to a country of low hills.

The stream pattern is braided and becomes quite sluggish in the Eugene area, and floods are common.

(6) Willamette Valley Geology

Rocks within the section are mostly glacial and alluvial sediments overlying older sediments. The low hills are composed of basalts or less resistant sedimentary rocks.

b. Cascade Sierra Mountains Province

The Cascade Range is divisible into the Western Cascades and High Cascades; it is best described as a great pile of volcanic rocks. The older Western Cascades are maturely dissected. Rocks range in age from Eocene to possibly early Pliocene. Eocene to lower Miocene rocks are chiefly pyroclastics with interbedded lava flows and lenses of waterlaid sediments. Middle Miocene Rocks are predominantly basaltic lavas which cap higher ridges and may be remnants of shield-type volcanoes. Younger rocks vary from pyroclastics to basalts. (ODGMI)

The High Cascades are the majestic volcanic peaks, cinder cones, and relatively undissected lavas on the east side of the Range. Original constructional form of most central vent volcanoes has been severely modified by glaciation. Most peaks are Plio-Pleistocene in age; Recent Flows and cinder cones are common. Lavas are dominantly basaltic andesites and olivine basalts. Some rhyolite and obsidian flows are presnet. Pumice blankets large areas. Intracanyon basalts of Pliocene age extend into the Western Cascades from the High Cascades. The highest peak is Mount Hood, 11,235 feet. (ODGMI) The Cascade Range is covered by the Coniferous Forest Sub-biomes, and in the southern

portion, supports a portion of the Broad Sclerophyll.

c. Columbia Plateaus Province

(1) Deschutes-Umatilla Plateau Physiography and Geology

The plateau is a north-sloping lava plateau or monocline bounded on the north by the Columbia River. The elevation varies from 600 to 3000 feet above sea level. The surface is deeply dissected by youthful streams separated by broad gently rolling inter-stream areas. Seabland channels eroded by glacial flood waters occur in the northern part. Rock types include horizontal sheets of upper Tertiary basalt varying in thickness from 10 feet to 200 feet. Volcanic ash and lapilli scoria and breccia are interbedded with the basalts. Sands, gravels, and clays are also found as well as other alluvial deposits washed from the adjacent mountains. Ancient lake deposits are also common.

(2) Blue Mountain Section Physiography and Geology

The Blue Mountains are a complex region of mountain ranges and mountainous areas, canyons, plateaus and basins. Elevations range from 2000 to 10,000 feet. The higher mountains are glaciated. The region is drained by the John Day River and other streams tributary to the Columbia River and Snake River. In many places pre-Tertiary rocks occur as islands surrounded by Tertiary lavas and pyro-clastics. In the northern, western, and extreme southern parts: the rocks are largely Tertiary pyroclastics and lavas from central vents and fissures. These Tertiary rocks are warped by large, broad, probably deep-seated folds. Major faults are common.

The Blue Mountain section is covered by the Montane Coniferous Forest and a part of the Palouse Prairie Grassland.

(3) High Lava Plains Physiography and Geology

The High Lava Plains are a young, uneroded surface with few established streams; largely interior drainage. Elevation varies from 3500 to 6000 feet above sea level. Quaternary rocks blanket the western part and consist of lavas, pumice, obsidian, and many small cinder cones. Tertiary rocks include basaltic, andesitic, and rhyolitic lavas; tuffs, and welded tuffs. Portions of the Montane Coniferous Forest and Cold Desert cover this section.

(4) Owyhee Upland Physiography & Geology

The Owyhee Upland has a moderately to highly dissected surface with few perennial streams. Elevation ranges from 2000 to 6000 feet above sea level. Late Quaternary lavas of limited extent occur north and west of Jordan Valley. Major faulting of middle Tertiary formations is generally north-south with typical fault block structures developed. These merge into the Basin and Range region to the south and west. The northern border is sharply defined where it lies on the intensely deformed pre-Tertiary rocks of the southern Blue Mountains. This section is covered mostly by the Cold Desert biome with a small portion covered by the Montane Coniferous Forest and Palouse Grasslands.

(5) Joseph Upland Physiography and Geology

The Joseph Upland is underlain almost exclusively by a thick succession of essentially flat-lying Miocene basalts with but

few thin sedimentary interbeds. Deeply eroded by numerous streams draining for the most part northward in narrow canyons with steep gradients. Elevations on the upland surface average between 3000 and 5000 feet. Palouse Prairie Grassland and Montane Coniferous Forest cover this section.

(6) Snake River Canyon Physiography & Geology

The Snake River has carved a deep (5652 feet at Hat Point), narrow, V-shaped, and locally precipitous canyon with an average gradient of approximately 10 feet per mile over an airline distance of 110 miles. It has cut through basalts of Joseph Upland and on into basement rocks of Blue Mountains to reveal a narrow, ribbon-like exposure of pre-Tertiary rocks throughout nearly the entire course of the canyon bottom. Older formations are principally Permo-Triassic metasediments and metavolcanics. The Montane Coniferous Forest generally covers this section.

d. Basin and Range Province

(1) Great Basin Physiography

The Great Basin lying in south central Oregon is covered by portions of the Montane Coniferous Forest and Cold Desert.

The Great Basin in Oregon consists of a belt 50 to 100 miles wide across the northern part of the Basin and Range Province. The mountains here differ from those to the south by being unfolded fault-blocks. Most of the escarpments are several hundred to 2000 feet high, with Steens Mountains having a steep eastward face rising 5000 feet above

the Alvord Desert. Some of the basins receive sufficient drainage to maintain permanent lakes but this is not the general rule, since dry (playa) lakes are the most common.

(2) Great Basin Geology

Relatively young volcanics, fragmental below and covered by lava make up many of the mountains. Faulting has resulted in the formation of the many escarpments found in the province. Alluvium usually fills the basins.

2. Minerals

a. Present Situation

The value of mineral production in Oregon for 1972 was $79.8 million, an increase of 2.5% over 1971. Nonmetals accounted for 90% of the total value.

(1) Nonmetals.

Stone, sand and gravel accounted for 78% of the total value of nonmetals produced. Sand and gravel pits are found in all of the sub-biomes, but the greatest concentrations are in the Northwest Coastal Coniferous Forest within the Willamette Valley where the greatest concentration of people exist. Stone quarries are found in the Montane and Northwest Coastal Coniferous Forest of western Oregon, in the Baker-LaGrande area within the Palouse Prairie Grassland, the Klamath Falls area of the Montane Coniferous Forest and other various localities within the state. Pumice localities occur in Deschutes, Baker, and Lake Counties. Cinders can be found throughout the state, where there has been volcanic activity. The value of lime produced in 1972 was down 15% from the preceding

year. Lime plants are located in Malheur and Multnomah Counties. Oregon led all the states in the value of gemstones produced for 1972 (Mineral Industry Surveys, USDI Bureau of Mines 1972). These consisted primarily of agates, sunstones, and petrified wood from the eastern part of the state.

(2) Metals.

Oregon nickel production was up 5% in 1972 compared with 1971. In 1972, Oregon was the sole producer of primary nickel in the United States. The Riddle nickel deposit of southwest Oregon lies within the Montane Coniferous Forest. Gold ore was shipped at a rate of 25 tons per day from the old Bald Mountain mine near Sumpter, and a gold placer was being worked 45 miles northwest of Baker. Mercury occurrences are scattered across the state. The areas that had the greatest past production are located in the southwestern, central and southeastern parts of the state. Titanium occurs in beach and terrance deposits along the Oregon coast within the Northwest Coastal Coniferous Forest. Uranium production has been recorded in central Oregon within the Juniper sub-biome and in the Lakeview area within the Montane Coniferous Forest.

(3) Fuels.

No production of petroleum has occured in Oregon. Interest in onshore exploration for oil and gas is increasing, however. Coal occurs within the Northwest Coastal Coniferous Forest of western Oregon and some minor occurances can also be found within the Montane Coniferous Forest and Palouse Prairie Grassland of eastern Oregon.

b. <u>Locatable, Leasable and Saleable Minerals</u>

The major locatable metallic minerals located in Oregon include antimony, ferrugenous bauxite, chromite, cobalt, copper, gold and silver, limonite, manganese, molybdenum, nickel, quicksilver, tungsten, uranium, zinc and lead.

Nonmetallic locatables include, asbestos, barite, bentonite, calcite, diatomite, garnet, graphite, gypsum, limestone, marble, mineral pigment, obsidian, perlite, pumice, refractory clay, semi-precious gems, silica, silica sand, and travertine.

Leasable minerals include, coal, salines, boran, soda ash, and zeolites.

Saleable minerals include, chert granules, clay, granite, limestone, pumice, sandstone, sand and gravel, scoria and cinders, silica sand, slate, tuff, and volcanic ash.

The Oregon State Department of Geology and Mineral Industries has published a map showing the principle mineral localities within Oregon.

c. <u>Oil and Gas Potential</u>

Certain geologic characteristics must be met before there is a potential for oil or gas. Approximately 1/5 of the state contains sedimentary rocks that satisfy one or more of the following geologic characteristics associated with the accumulation of commercial deposits of oil and gas:

(1) there must be an abundant source of petroleum-generating material in the form of marine and sometimes nonmarine animal

and plant life;

(2) a porous, permeable zone of sufficient thickness to contain large quantities of oil and gas;

(3) an overlying impervious bed;

(4) an underlying seal, such as a water-saturated zone or a pinch-out of the oil bearing stratum; and

(5) some type of structural feature, or a discontinuity of the porous, permeable beds, or a combination of the two that provided a trap in which the petroleum or natural gas accumulated and was preserved.

To date none of the areas explored and drilled have bound these characteristics in the proper combination to yield a producing well although this does not preclude the chances of a future discovery.

Figure 8 shows the favorable areas for petroleum occurrence. The primary areas of interest are the Coastal Tertiary Marine Basin, Central Oregon Cretaceous Embayment, West Snake River Tertiary Lake Basin and Harney Tertiary Lake Basin (Figure 3).

Marine sediments of great thickness occur in the northwest corner of the state within the Coastal Tertiary Basin. These sediments pinch out and interfinger with volcanic rocks of the Coast Range. Also within the Willamette Valley, geologic structures conducive to petroleum accumulation are present (Newton, V. C, Jr., 1969, p. 5). These structures include major faulting, secondary faulting, local warping, and facies changes along the west side of the Willamette Valley. Within

the eastern margin of the basin along the Western Cascades deep drilling has confirmed marine sediments interfingered with continental volcanics. This ancient shoreline is a precursor for stratigraphic-type accumulations. More detailed geological and geophysical studies including drilling may yield a potential oil and/or gas deposit within this basin.

The Central Oregon Cretaceous Embayment has been an area of prospective interest for oil and gas. Figure 9 shows a possible Central Oregon environment during the Cretaceous period (Figure 10) 75 million years ago. Figure 11 shows a typical oil trap that might occur in Central Oregon.

Oil shale occurring in a small deposit at Shale City in Jackson County tests as commercial grade, yielding 36 gallons per ton. The Oregon Department of Geology and Mineral Industries estimates the shale body to contain 150,000 tons of high-grade shale (ODGMI Bulletin 64, 1969, p. 279).

The Western Snake River Basin covers an area of about 2,000 square miles along the Central Oregon-Idaho boundary. The average elevation is about 2,300 feet. Within Oregon this section is bounded by the Blue Mountains pre-Tertiary rocks on the north and by Tertiary lavas on the south and west. Middle Miocene to upper Pliocene nonmarine sedimentary rocks, consisting mainly of tuffaceous shales, sandstones, and conglomerates with intercalated lavas, fill the western part of the basin. These Tertiary rocks in Oregon are at least 10,000 feet thick. Surface

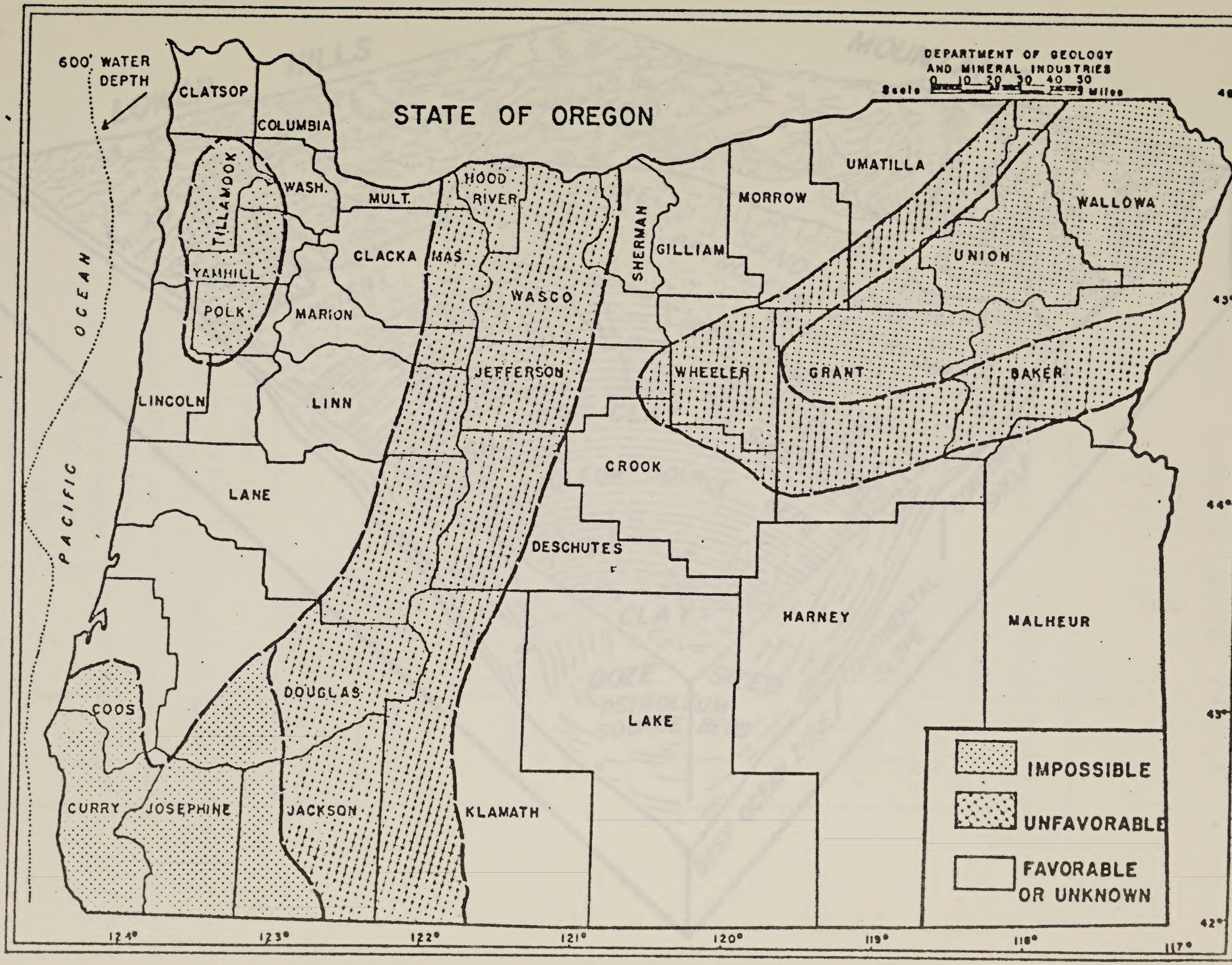


FIG. 8

POTENTIAL GAS COMMITTEE
PETROLEUM POTENTIAL
1973

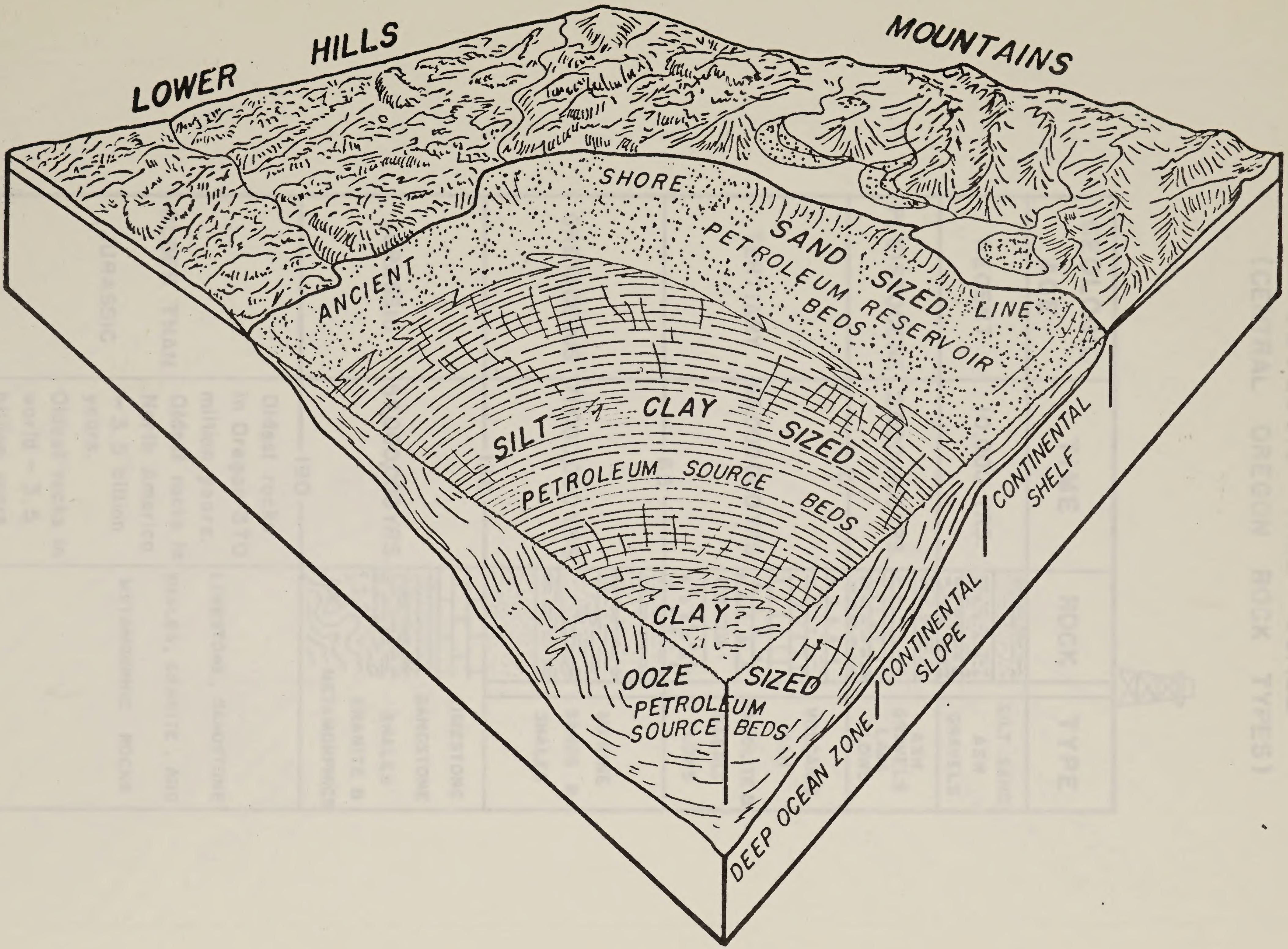
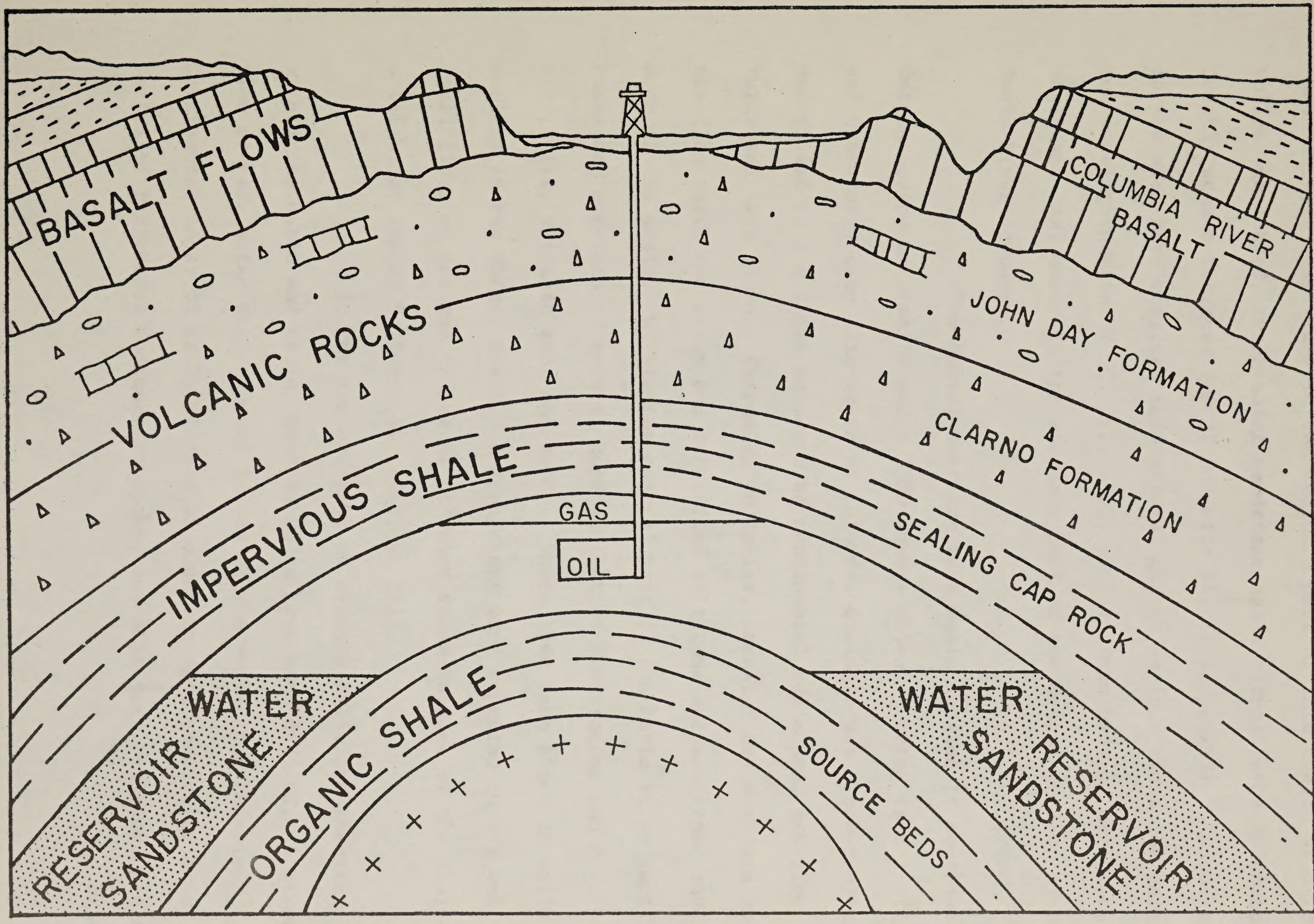


FIG. 9

CENTRAL OREGON 75 MILLION YEARS AGO

GEOLOGIC TIME SCALE
(CENTRAL OREGON ROCK TYPES)

GEOLOGIC AGE	TIME	ROCK	TYPE
RECENT	10,000 YRS.		SILT SAND ASH GRAVELS
PLEISTOCENE	2,000,000 YRS.		ASH GRAVELS LAVA FLOWS
	2		
TERTIARY	63,000,000 YRS.		VOLCANIC ASH RHYOLITE & BASALT FLOWS
	65		
CRETACEOUS	71,000,000 YRS.		MARINE SANDS & SHALES
	136		
JURASSIC	54,000,000 YRS.		LIMESTONE SANDSTONE SHALES GRANITE & METAMORPHICS
	190		
OLDER THAN JURASSIC	Oldest rocks in Oregon 370 million years. Oldest rocks in North America – 3.5 billion years. Oldest rocks in world – 3.5 billion years.	LIMESTONE, SANDSTONE SHALES, GRANITE, AND METAMORPHIC ROCKS	



TYPICAL OIL TRAP IN ANTICLINAL FOLD

FIG. 11

indications of oil occur in the southern part of this region at Sand Hollow where hard, fresh-water sandstone has a petroliferous odor on freshly broken surfaces (ODGMI Bulletin 64, 1969, p. 292). Ranchers in the area have utilized this natural gas at various times for heating and cooking (Newton, V. C. Jr., 1963, p. 3). Thin beds of carbonaceous shale and coal occur in the southern part of the Oregon portion of the Snake River downwarp.

The Harney Tertiary Lake Basin located in southeastern Oregon covers an area of about 1500 square miles. During late Tertiary and Quaternary time this basin of internal drainage was block-faulted and filled with a thick sequence of continental sediments, ash-flow tuffs and lava flows. Extrusive volcanics, basalt flows overlain by ash-flow tuffs and flows and stratified siltstone and sandstone cover much of the basin. Within the central part of the basin these Tertiary rocks are overlain by several hundred feet of Pleistocene and Holocene clay, silt, volcanic ash, and sands. There have been about 12 wells drilled in the Harney Basin. Hydrocarbons were reported in one well and small flows of gas and traces of oil were found in some of the shallow drill holes (ODGMI Bulletin 64, 1969, p. 293).

In the general area of Klamath Falls and Lakeview within the basin and range, several holes have been drilled. A strong flow of gasy water was reported in one of the wells near Lakeview. Continental rocks of early Miocene or older in age, consisting of a series of tuffaceous sedimentary rocks, and adesitic lava flows are overlain

by a nonmarine dacitic, and rhyolitic tuffaceous nonmarine sedimentary rocks that with an interbedded basalt sequence. The whole unit may be 7000 feet thick. Above this, at least 5000 feet of Miocene and Pliocene basaltic and andesitec flows interbedded with sedimentary rocks can be found. Further west within the Klamath Falls area 3000 feet of basaltic lava flows and interbedded nonmarine sedimentary rocks of Pliocene age are exposed.

d. Summary and Conclusion

The Coastal Tertiary Marine Basin may be the most likely area in Oregon to produce commercial quantities of oil or gas because it has source beds of organic rich marine shales both along the Western side of the Coast Ranges and in the northern Willamette Trough, overlain locally by sandstone and siltstone units which could serve as reservoir rocks. Also anticlinal structures are present in the area, many of which have not been drilled. Marine formations overlain by volcanic rocks are found in Central Oregon near Paulina. A marine sedimentary unit more than 9000 feet thick outcrops southeast of Madras (Swanson, 1969). The western part of the Blue Mountains has pre-Tertiary marine strata with interbedded volcanics. A few of the test holes drilled into the marine strata have revealed petroleum indicators, and some minor surface indications of petroleum are found in the area.

D. Soils

The system of soil classification in the U.S. is similar to the systems used to classify plants and animals. Soil classification utilizes the soils' physical, chemical and mineralogical properties as well as factors which influence plant growth. Climate, soil depth, coarse fragment content and soil drainage are a few of the items which influence plant growth and are used to separate one kind of soil from another.

There is a tremendous variation in kinds of soils occurring in Oregon. This variation decreases as one ascends the catagorical rungs of the classification scheme. Each sub-biome contains a group of soils, at some higher level of classification, which are similar in many characteristics. This is because climate and vegetation are reflected in soil development just as climate and soils are major items in the evolution of a plant community.

On the above premise some of the major soil series will be discussed for each sub-biome. It must also be remembered that the soils in each sub-biome are quite variable when considered at the lower classification categories (the more detailed separations). There are transitional types of soils which occur in more than one sub-biome. The major soils discussed for each biome occur extensively and are examples of numerous soil series with similar characteristics.

Soils discussed will be identified in one of two ways. Soil series officially established by the Soil Conservation Service will be

identified by name. Soil series not officially established will be identified by numerals.

1. Definitions

General definitions of terms used in the following sections are as follows:

a. Soil Texture

Clayey -- Soils containing over 35% clay in the fine earth fraction.

Clayey-skeletal -- Soils containing over 35% coarse fragments by volume and more than 35% clay in the fine earth fraction.

Loamy-skeletal -- Soils containing greater than 35% coarse fragments by volume and the fine earth fraction contains less than 35% clay.

Fine-loamy -- A soil containing 15% or more particles which are greater than 0.1 MM in size and contains 18 to 35% clay in the fine earth fraction.

Coarse-loamy -- A soil containing 15% or more particles which are greater than 0.1 MM in size and contains less than 18% clay in the fine earth fraction.

b. Climate

Temperature - Mesic soils have mean annual temperatures of 47°F. or more. Frigid soils have mean annual temperatures less than 47°F.

Moisture - Xeric soils are dry for 60 consecutive days, 7 out of 10 years. Udic soils are not dry for 90 cumulative days nor 60 consecutive days.

2. Northwest Coastal Forest

Thomas, Pomerening and Simonsen (1969) listed the soils which occur in the uplands adjacent to the Willamette Valley.

The Jory series is a red, clayey soil occuring in xeric-mesic zone at lower elevations adjacent to the interior vallyes. Honeygrove soils are similar to the Jory soils except they occur at intermediate elevations in the udic-mesic zone. Both soils are located in the Cascade and Coast Range Mountains. The Kinney soils are brown, fine-loamy and Hembre soils are red, fine-loamy. Kinney and Hembre soils also occur in the udic-mesic zone. Kinney soils are located at intermediate elevations in the Cascade Mountains. Hembre soils are located at intermediate elevations in the Cascade and Coast Range Mountains. Astoria soils (USDA, 1964) are brown, fine soils occuring in the udic-mesic zone. These soils are dominantly located on the west side of the Coast Range Mountains and areas in the north which drain into the Columbia River.

Digger and 564 soils are brown, loamy-skeletal and are located on sedimentary bedrock in the Coast Range Mountains. 564 soils are less than 20 inches to hard bedrock. Both of these soils occur in the udic-mesic zone. The brown, loamy-skeletal Henline and Goodlow soils occur in the udic-frigid zone in the high elevations of the Cascade Mountains.

Bureau of Land Management (1972) has mapped extensive acreages of 381 and 371 soils in the xeric-mesic zone of the Coast Range Mountains. The 381 soils are red, clayey-skeletal while the 371 soils

are brown and loamy-skeletal. Orford soils (USDA, 1970) are located on the southern Oregon coastal areas. These soils are brown, clayey and occur in the udic-mesic zone. The brown, coarse-loamy Siskiyou soils occur in the Siskiyou Mountains and are in the xeric-mesic climatic zone.

Some soil properties and interpretations for these soils listed for the above biome are listed in Table 1. Detailed soil reports must be referred to for specific ratings under various conditions for these soils and for other soil series not listed above.

3. Montane Forest

Vance, Lindsay and Simonson (1969) identify three major soil series in the forested uplands of the Grande Ronde Drainage Basin. Tolo soils are brown and contain less than 65% volcanic ash. They occur in the udic-frigid zone at elevations between 2,200 and 6,500 feet in the Wallowa Mountains. Couse soils are brown, silty and occur in the xeric-mesic zone in the Wallowa Mountains at elevations between 2,500 and 4,500 feet. The Anatone soils are shallow, brown, and loamy-skeletal. They occur in the Wallowa Mountains in the xeric-frigid zone at elevations between 3,500 to 5,500 feet. These soils are generally non-forested.

Dyksterhuis et.al. 1969 also list clayey, brown Fronhofer and Hankins soils as occurring in the Blue Mountains. Fronhofer soils occur in the xeric-frigid zone at elevations between 3,500 and 5,200 feet. Hankins soils occur in the xeric-frigid zone at elevations between 4,200 and 5,200 feet. Klicker frigid soils are well drained, dark brown, stony silt loams occurring in the basalt uplands (Table 2).

Table 1 - Engineering Classifications, Hazard Ratings, and Relative Productivity for Selected Soil Series

Soil Series	Unified Class (subsoil)	Hydro Group	Landslide Hazard 35-60% slopes	Landslide Hazard 60% + slopes	Erosion Hazard 1/ 35-60%	Erosion Hazard 1/ 60% + slopes	Compaction Hazard 2/	Productivity 3/ D. Fir Site Class
Jory	CL	C	mod-stable	unstable	med	high	high	III
Honeygrove	MH	C	mod-stable	unstable	med	high	high	II
Kinney	SM	B	mod-stable	mod-stable	med	high	medium	II
Hembre	ML	B	stable	mod-stable	med	high	medium	II
Astoria	MH	B	unstable	unstable	high	very high	high	I
Digger	SM	C	unstable	unstable	med	high	medium	IV
564	GM	D	unstable	unstable	med	high	low	V
Henline	GM	C	stable	mod-stable	med	high	low	III
Goodlow	GM	B	stable	mod-stable	low	med	low	IV
381	ML	C	mod-stable	unstable	med	high	high	IV
371	SM	B	stable	mod-stable	med	high	low	IV
Orford	MH	C	mod-stable	mod-stable	med	high	high	II & III

1/ Based on bare soil surface
2/ Based on reduction of pore space which impedes root development and air and water movement.
3/ USDA 1949 Technical Bulletin No. 201

Table 2 - Engineering Classifications, Hazard Ratings & Relative Productivity for Selected Soil Series

Soil Series	Unified Classification (Subsoil)	Hydrologic Group	Compaction Hazard 1/	Erosion Hazard 2/	Productivity in Site Index D. Fir	Larch	P. Pine
Anatone	GM or ML	D	low	medium	-	-	-
Couse	ML-CL	C	high	low	-	-	-
Fronhofer	CH or SC	C	high	medium	75	-	63
Hankins	CH	C	high	med-high	-	-	-
Tolo	ML-CL	B	medium	medium	100	110	-
Klicker	SM	C	low	medium	80	-	75

1/ Based on reduction of pore space which impedes root development and air and water movement.

2/ Based on a bare soil surface.

4. Cold Desert and Juniper

Generally, the soils in the southeastern portion of the state are somewhat different than the soils occurring the the Deschutes Drainage Basin. The major soils in the Malheur Lake, Malheur River and the Owyhee Drainage Basin will be discussed first.

Lindsay et.al. (1969), Lovell et.al. (1969(a)), and Lovell et.al. (1969(b)) describe the soils of southeastern Oregon. All the soils are in the xeric moisture regime zone.

Classification unit 1 mesic soils are well drained brownish gray and occur on nearly level fans and bottomlands. Unit 10 mesic soils are somewhat poorly drained, grayish brown silt loams and occur on nearly level stream bottoms. Unit 55 mesic soils are well drained, light brownish gray gravelly loams and occur on old fans and terraces. Unit 75 frigid soils are well drained, light brownish gray, stony loam and occur over basalt on gently undulating to rolling lava plateaus.

Unit 76 frigid soils are shallow, well drained, light brownish gray, stony silt loams and occur over basalt on gently undulating to rolling lava plateaus. Unit 25 frigid soils are well drained, light gray, silt loams and occur on lake basin terraces which are underlain by lacustrine sediments.

Norgren et.al. (1969) discuss the soils in the Deschutes Drainage Basin. This basin contains the major portions of the Juniper sub-biome. All the soils occur in the xeric moisture regime zone. A description of some of the major occurring soils follows:

Bakeoven soils are mesic, very shallow, well drained, dark brown, stony loams occurring on steep basalt uplands. Deschutes mesic soils are well drained, dark brown, coarse-loamy and are derived from pumice. Lapine frigid soils are excessively drained, pale brown, gravelly loamy sands occurring in the uplands. They are derived from pumice. Lickskillet mesic soils are shallow, well drained, dark grayish brown, stony loams which occur on steep basalt slopes.

Tub mesic soils are well drained, dark brown clay loams which formed from sedimentary rocks. They occur on the rolling uplands. Unit 96 is "non-soil". It is rock outcrop, talus slopes, and canyon escarpments.

Table 3 lists some properties and interpretations for the selected soils in the cold desert and juniper biomes.

5. Broad Sclerophyll

Power and Simonsen (1969) describe the soils occurring in the broad sclerophyll and biome. Carney soils are xeric, mesic, well drained, dark brown, clay and occur on footslopes. Freezener soils are xeric, mesic, deep, well drained, reddish brown, loams. They are formed over basalt and occur in the steep uplands. Josephine soils are xeric, mesic, moderately deep, well drained, reddish brown clay loams. They are formed over metamorphased sandstone and shale and occur in the uplands. Pearsoll soils are shallow, xeric, mesic, reddish brown clays. They are formed over serpentine bedrock and occur in the foothills and uplands. These soils are unique as they contain sufficient magnesium to

Table 3 - Engineering Classification, Hazard Ratings and Relative Productivity for Selected Soils

Soil Series	Unified Classification (subsoil)	Hydralogic Group	Compaction Hazard 1/	Erosion Hazard 2/	Productivity Pot. forage yield (lbs/A)	Total vegetation lbs/A
1	ML	B	med	low	--	1,500
10	ML	C	med	low	--	800
25	CL	C	med	low	--	-
55	GM	D	low	med	--	800
75	ML-CL	D	med	med	--	350
76	CH	D	med	med	--	550
Bakeoven	GM	D	med	med	400	-
Deschutes	SM	A	low	high	--	-
Lapine	SW	A	low	low	50-100	-
Lickskillet	GC or SC	D	med	high	700-800	-
Tub	CH	C	high	high	800-1100	-
96	GP	D	low	low	--	100

1/ Based on reduction in pore space which impedes root development and air and water movement.

2/ Based on a bare soil surface.

inhibit many plant species. Siskiyou soils are xeric, mesic, moderately deep, excessively drained, yellowish brown sandy loams. They are formed on granitoid rocks and occur in the foothills and uplands. Medford soils are xeric, mesic, deep well drained, black silt loams. They are formed in alluvium and occur on terraces and valley bottoms.

Table 4 lists some characteristics of the above soils.

6. Palouse Prairie

The soils occurring in the Powder Drainage Basin are discussed by Lindsay and Simonson (1969). Soils occurring in the Umatilla Drainage Basin are discussed by Norgren and Simonson (1969). The dominant soils in this sub-biome are xeric and mesic.

The three soils which occur extensively in the Powder drainage are Bs., Ruckles, and Salisbury series. The Bs. soils are well drained, grayish brown, shaly loams which occur on grassy uplands. Ruckles soils are shallow, well drained, dark grayish brown, very stoney clayey-skeletal, and occur over basalt in the grassy uplands. Salisbury soils are well drained, very dark brown, fine textured, and occur on dissected terraces in stratified sediments.

The following section briefly describes the soils that occur extensively in the Umatilla Palouse Prairie sub-biome. The Condon soils are well drained, dark brown, silt loams which were derived from loess. Morrow soils are well drained, dark grayish brown silt loams derived from loess and occur on the basalt uplands. Quincy soils are deep, somewhat excessively drained, grayish brown, fine sands. They are formed from wind-blown fine sand and loamy sands. Ritzville soils are

Table 4 - Engineering Classification, Hazard Ratings and Relative Productivity for Selected Soils

Soil Series	Unified Classification (subsoil)	Hydrologic Group	Compaction Hazard 1/	Erosion Hazard 2/	Productivity
Carney	CH	D	high	med-high	--
Freezener	CL	B	med	high	--
Josephine	MH	C	high	high	SI = 140 (D. Fir)
Medford	CL or ML	B	med	low	6-7 T of hay/A
Pearsall	CH	D	high	high	--
Siskiyou	SM	B	low	high	S.I. = 110 (sugar pine)

1/ Based on reduction in pore space which impedes root development and air and water movement.

2/ Based on a bare soil surface.

deep, well drained dark brown silt loams. They are formed in windblown silt on the uplands. Snell soils are moderately deep, well drained, dark grayish brown, stony silt loams. They formed from basalt and windblown silt and occur on the canyon walls. Walla Walla soils are very deep, well drained, dark brown silt loams. They formed in wind-blown silt. Some characteristics of the above soils are listed in Table 5.

Table 5 - Engineering Classification, Hazard Ratings and Relative Productivity for Selected Soils

Soil Series	Unified Classification (subsoil)	Hydrologic Group	Compaction Hazard 1/	Erosion Hazard 2/	Total lbs/A	Usable A/AUM	Wheat bu/A
Bs	ML-CL	B	med	high	--	--	--
Ruckles	CH or CG	C	med	high	1200-1600	--	--
Salisbury	CH	C	high	med			20-40
Condon	ML or CL	B	med	med	900	--	30
Morrow	CL	C	med	med	700-800	--	25
Quincy	SP or SM	A	low	high(wind)	--	3-4.3	6 T.hay/A
Ritzville	ML	B	med	high	--	1-2	25
Snell	SM or SC	C	med	high	--	--	--
Walla Walla	ML or CL	B	med	med	--	--	60

1/ Based on a reduction in pore space which impedes root development and air and water movement.
2/ Based on a bare soil surface.

E. Water

The characteristics of the water resource vary markedly across Oregon, and the boundaries for areas with similar characteristics will differ from those of the biomes and sub-biomes and of the physiographic and geologic areas of Section C. The subdivisions of Oregon used in this section for describing the water resource were adapted from the Columbia-North Pacific Region Comprehensive Framework Study, Appendix V, and are shown in Figure 12.[1/] The description of the water resource within each of these subdivisions will include the characteristics of the surface water, the ground water, the chemical quality and the sediment load of these waters.

1. Coastal Area

This subdivision includes all the small coastal rivers west of the Coast Range in the northern part, and those large coastal rivers which head in the Cascade Mountains in the southern portion of the State. The northern portion is included in the Northwest Coastal Coniferous Forest and the southeastern portion is included in the Broad Sclerophyll and Palouse Prairie Grassland.

a. Surface Water

The coastal streams in the northern portion of this subdivision yield the greatest amount of annual runoff - about 100 inches for both the Wilson and the Siletz Rivers. The runoff decreases southward to about 35 inches per year for the Umpqua and the Coquille River basins and 30 inches for the Rogue Basin (C.N.P.S., page 770).

1/ This study will hereinafter be abbreviated as C.N.P.S.

Winter rainfall is the major source of runoff, particularly in the northern portion, with a secondary source from snowmelt in the Upper Umpqua and Rogue Basins. Those streams with rainfall as the main source of runoff have a seasonal peak from December to January and a seasonal low in August. Those streams whose runoff is supplemented by snowmelt have a secondary peak in May and June (C.N.P.S., page 786).

The quality of the surface waters is generally very good; the streams are very dilute and very soft. In the northern portion, the total dissolved solids range from about 30 to 50 mg/l, with the range in hardness from 8 to 30 mg/l with calcium and bicarbonate as the major ions. Some of the lower tributaries of the Rogue River contain water with a higher portion of magnesium bicarbonate (C.N.P.S., pages 847-849, and figure 765).

Suspended sediment yield from the coastal area is generally low. About 89 percent of the area yields 0.1 to 0.2 acre feet per square mile per year. Portions of the Upper Rogue yield 0.02 to 0.1 AF/SMY and areas around the Upper South Fork of the Umpqua, the South Fork of the Coquille River, and the Upper Wilson River yield 0.2 to 0.5 AF/SMY.

b. Ground Water

Most of the area is classified as yielding 1 to 20 gallons per minute of water to a well. An exception is the southwestern portion of the west slope of the Cascade Mountains whose groundwater yield is unknown but which is underlain by volcanic material capable of

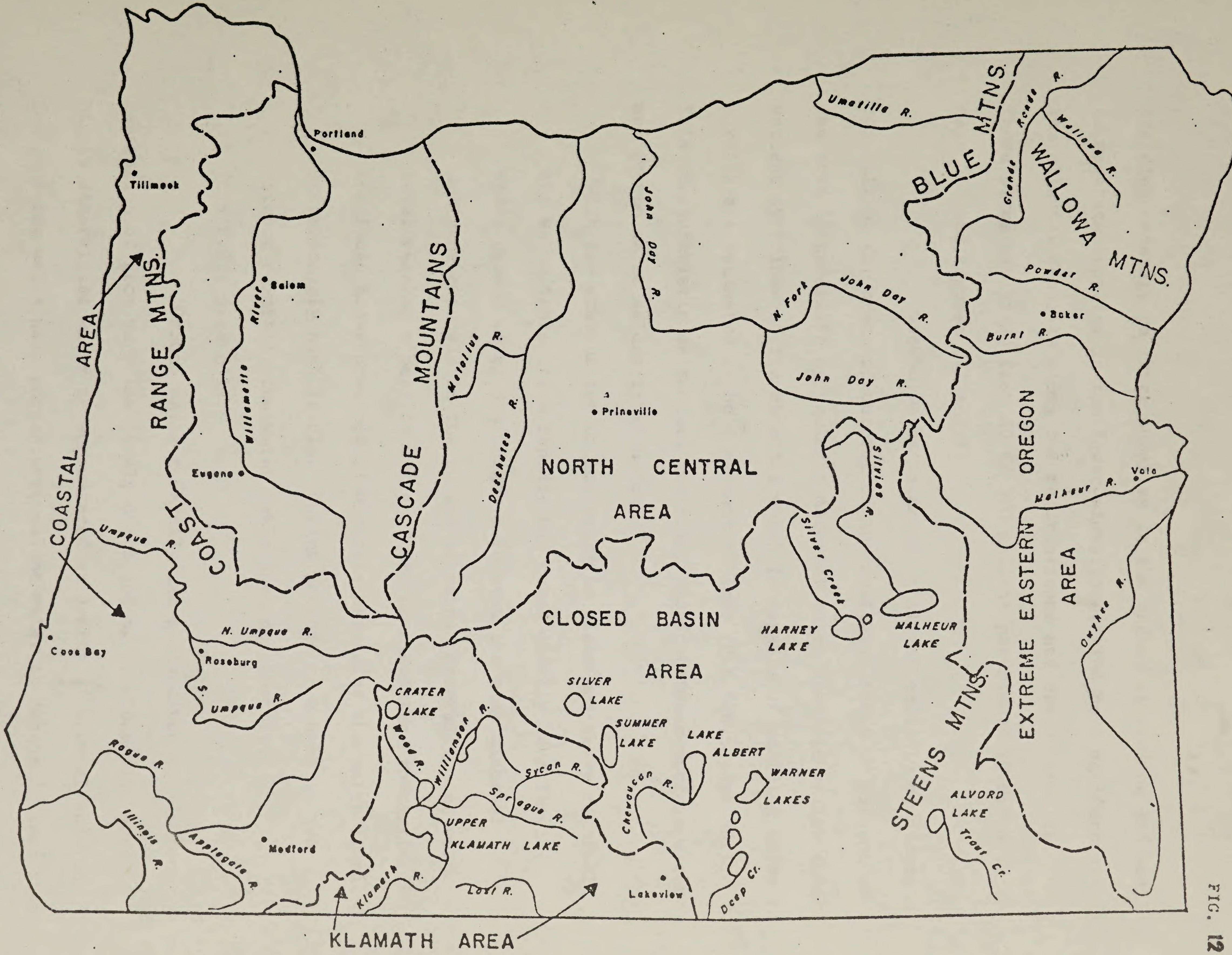


FIG. 12

WATER RESOURCE AREAS-OREGON

yielding moderate to large supplies in the higher elevations and small to moderate supplies in the lower elevations. The best aquifers are the alluvial deposits along the major streams and beach deposits. These sites may yield from 20 to 500 gallons per minute (C.N.P.S., page 855 and Figures 771 and 772).

Ground water recharge is almost entirely by direct rainfall on the areas of outcrop of the aquifer. About 80 percent of the area is underlain by geologic material whose specific yeilds (the percent by volume of the material which is capable of yielding water to a well) are estimated to be 2 percent or less (C.N.P.S., page 861). This characteristic determines the relationship between surface water and ground water as described below:

> "With the combination of low specific yield and heavy rainfall, the water table rises rapidly and comes quickly to a level where ground water discharges into even the most minor of drainage channels in the rugged terrain. Generally, the water level reaches a peak in early winter or midwinter; thereafter, continued heavy precipitation merely maintains the water level at relatively high levels. During periods of a week or two without rainfall, the water table declines sharply."
> (C.N.P.S., page 861)

Ground water generally has a dissolved solids concentration of from very low levels up to 500 mg/l. Commonly, more highly mineralized water is encountered at depths of several hundred feet. A few wells have encountered saline water at depths of less than

100 feet. Iron and hydrogen sulfide are problems in some supplies. Boron concentrations of 1 to 20 mg/l are found in the Medford area along with excessive flouride (C.N.P.S., page 866).

2. Willamette Area

This area includes the Willamette River and its tributaries and extends from the crest of the Coast Range east to the crest of the Cascades and from the Columbia River south for 150 miles. This area is included in the Northwest Coastal Coniferous Forest.

a. Surface Water

Streams which enter the Willamette River from the Coast Range (west side of the valley) have a distinctly different hydrograph shape than the streams from the Cascade Mountains (east side of the valley). The west side streams have one main peak flow period per year, from December through January, as a result of heavy winter rains with relatively little snow. Rainfall on the crest of the Coast Range averages from 100 to 200 inches per year in the northern part, and decreases to 60 to 90 inches per year in the southern portion. On the east side of the valley, winter snowpack may form a significant part of the yearly runoff and this causes a second peak in the hydrograph from these streams in April and May. aunoff from the entire basin averages about 43 inches per year (C.N.P.S., pages 691 and 713 to 717).

The quality of surface water in the Willamette area is generally good with the dissolved solids content ranging from 38 mg/l to about 95 mg/l (C.N.P.S., page 745 and Figure 654). The surface

waters contain ions of the calcium magnesium bicarbonate type. Of particular significance is the lack of an increase in the salt load from irrigation return flows since the earliest chemical analyses in 1910. This low salt load (about 0.02 ton/acre/year) is due in part to the humid zone and the well leached soils that contain only small quantities of soluble salts. The total dissolved solids load for the Willamette basin is estimated to be about 0.28 ton/acre/year (C.N.P.S., page 745-746).

About 80 percent of the annual sediment discharge occurs during the high rainfall and high runoff period from November to February. About 90 percent of the area yields from 0.1 to 0.2 acre-feet/square mile per year. Suspended sediment concentrations for large streams range from less than 100 mg/l to about 400 mg/l, but may exceed 2000 mg/l during major floods (C.N.P.S., page 750 and Figure 657).

b. Ground Water

Perhaps 65 percent of the Willamette area is underlain by geologic material which yields 1 to 20 gallons per minute to wells. Yield from the volcanic rocks of the Cascade Mountains is generally unknown, however, the character of streamflow in this region indicates yield to wells may be moderate to large. The best aquifers are found in the alluvial deposits of the Willamette River and its major tributaries. This material will yield 20 to 500 gallons per minute (C.N.P.S., page 755 and Figure 662).

Groundwater quality is generally good with low flouride and boron concentrations and low sodium absorption ratio. Iron concentrations may be in excess of recommended limits in some

wells. Most ground water has dissolved solids concentrations of less than 500 mg/l. Water from marine strata may be moderately to highly saline at depth of a few hundred feet. In a few places, saline water may be encountered at less than 100 feet (C.N.P.S., page 760).

3. North Central Area

This area is bounded on the west by the crest of the Cascade Mountains, on the north by the Columbia River, on the east by the Blue Mountains, and on the south by the topographic divide which bounds the Deschutes and John Day Rivers. The east slopes of the Cascade Mountains and the Lower Crooked River (a tributary of the Deschutes) are included in the Montane Coniferous Forest, in addition to the west slopes of the Blue Mountains and the upper reaches of the John Day River Basin. The Cold Desert covers the upper Crooked River Basin and portions of the Lower John Day and Deschutes River Basins. There is also a strip of Cold Desert adjacent to the Columbia River from north of Pendleton west to the John Day River. The Juniper Woodland occupies the higher elevations in the Crooked River Basin. Finally, the Palouse Prairie Grassland covers the Umatilla River Basin from the foothills of the Blue Mountains south and west to include much of the John Day River Basin.

a. Surface Water

Surface runoff from the north central area is dominated by the variation in precipitation and snowfall across the area. The east slopes of the Cascades may have from 45 inches to

120 inches of precipitation with most of this in the form of snow at the higher elevations. Runoff from these areas drains into the Deschutes River and gives this stream a pronounced spring snowmelt peak in May and June in addition to its winter rainfall peak in March (C.N.P.S., Figure 439). The Deschutes River yields about 7 inches of runoff per year (C.N.P.S., page 546). The central portion of the north central area shows a sharp drop in annual precipitation to a range of from 10 inches to 25 inches. This is mostly winter rainfall.

The streams show a corresponding drop in water yield to about 3.5 inches per year for the John Day River (C.N.P.S., page 546). On the east side of the north central area, the Blue Mountains cause an increase in annual precipitation from about 12 inches at Pendleton to about 35 inches at the crest of the mountains. Much of the annual yield of 2.5 inches of runoff from the Umatilla River comes from snow-melt in the Blue Mountains (C.N.P.S., page 553).

The quality of the surface water in this area is extremely variable. In the upper reaches of most streams, these waters contain a low calcium magnesium bicarbonate concentration. Mineralization increases downstream where irrigation return flow and natural springs increase the dissolved solids content. For example, the maximum dissolved solids in the Upper Deschutes River near Bend is 54 mg/l and this increases to 113 mg/l below Pelton Dam (C.N.P.S., page 608 and Figure 510).

Sediment yield may be quite high in the localized areas. The highest concentrations occur during peak flows and a maximum

concentration of 135,000 mg/l was observed in one stream within the north central area. The John Day River had a maximum observed concentration of 106,000 mg/l of suspended sediment during the December 1964 flood. This stream was estimated to have transported 9.2 million tons of sediment from December 21-31, 1964. This was more than eight times the amount discharged during the entire 1963 water year from October 1, 1962, through September 30, 1963 (C.N.P.S., page 611). The major portion of the area shows a sediment yield of 0.02 to 0.1 acre-feet per square mile per year. The east slope of the Cascades is estimated to yield 0.1 to 0.2 AF/mi^2/Y. The area from the Lower Deschutes east to Heppner yields 0.2 to 0.5 AF/mi^2/Y, as does the areas around Ochoco and Prineville Reservoirs on the Crooked River. Turbidity of the Lower Crooked River below Prineville Reservoir is periodically high because of suspended sediments carried into the reservoir by Bear Creek, a tributary of the Crooked River. This local suspended sediment problem is the subject of an intensive cooperative study by the BLM, Forest Service, Oregon State University, Geological Survey, and the Game Commission. The most serious source area for suspended sediment appears to be that portion of the Palouse Prairie Grassland sub-biome from Pendleton to Milton-Freewater (C.N.P.S., Figure 511).

b. Ground Water

The yield of much of the volcanic material on the east side of the Cascades and west slope of the Blue Mountains has never been tested. Alluvial deposits and some of the younger volcanic

material which is under or adjacent to large streams may yield up to 500 gallons per minute to wells. There is a large aquifer of alluvium, volcanic material, and coarse lake deposits which extends from the Columbia River south to Maupin on the Deschutes River, east to Heppner, and northeast to Milton-Freewater. This aquifer is capable of yielding 100 gallons per minute to 200 gallons per minute. The area from Arlington through Pendleton to Athena is particularly productive (C.N.P.S., Figure 517).

Groundwater forms a significant portion of the annual flow from rivers which originate on the east slope of the Cascade Mountains. The Deschutes River receives enough ground water to sustain a high summer flow rate. The Metolius River, a tributary of the Deschutes, averages 97 percent of its discharge from ground water (C.N.P.S., page 629). In fact the ground water discharge is so high that it suggests some interbasin diversion from the west side of the Cascade Mountains.

Groundwater from the alluvial deposits and the younger volcanic material generally has dissolved solids concentrations of less than 350 mg/l and is moderately hard to hard. Boron and flouride concentrations are low. Water from other materials may have dissolved solids concentrations less than 500 mg/l and the water is moderately hard to very hard. Flouride concentration may range up to 5 mg/l.

4. Extreme Eastern Oregon

This region includes all those basins whose streams drain into the Snake River. This area is bounded by the Blue Mountains on the northwest and the boundary runs south and east along the topographic

divide between the Snake River tributaries and the Malheur Lake-Steens Mountain area to the southwest. The extreme eastern Oregon area contains the Cold Desert south of the Malheur River, the Palouse Prairie Grasslands from the Malheur River north to the Wallowa Mountains (and including a small area of Palouse Prairie around Enterprise), and the Montane Coniferous Forest in the northeast corner of the State.

a. Surface Water

The major rivers are, from south to north, the Owyhee, Malheur, Burnt, Powder, Imnaha, and Grande Ronde. The annual runoff is probably less than 1 inch for that area south of the Malheur River, about 5 inches for the area between the Malheur River and the Wallowa Mountains, and about 8 inches from that area north of the Wallowa Mountains (C.N.P.S., Figures 308 and 359). Snowpack is heavy in the higher elevations in the Blue and Wallowa Mountains where the annual precipitation may be as high as 80 inches. Much of the lower elevation terrain away from the influence of the mountains may have annual precipitation of about 8 inches with intermittent snow cover. Streamflow from rivers in this area all show a single annual flood peak in April and May as a result of snowmelt (C.N.P.S., Figures 311, 314, 319, 320, and 367).

The Owyhee, Malheur, and Powder rivers are fairly dilute (100-200 mg/l) with calcium bicarbonate mineral in the upper reaches during high flow periods. For the remainder of the year these waters change to a sodium bicarbonate composition (C.N.P.S., page 456). Mineralization increases significantly downstream. On the Malheur River at Ontario, for example, the chemical composition of the water

is sodium bicarbonate in the winter and sodium sulfate during the irrigation season, with an average concentration of 1040 mg/l dissolved solids (C.N.P.S., page 456). By comparison, the waters of the Grande Ronde River in the upper reaches are of the calcium bicarbonate type with a concentration of about 75 mg/l. As this river enters the Snake River the water is still of the calcium carbonate type, with some slight increase in sodium and sulfate and a slight increase in concentration to about 100 mg/l (C.N.P.S., page 523).

Sediment yield from the headwaters of the Owyhee and Malheur Rivers is quite low - 0.02 to 0.1 acre-feet/square mile/year. The basins of the Burnt and Powder Rivers together with the remainder of the Malheur and Owyhee basins yield 0.1 to 0.2 acre-feet/square mile/year. Most of the area north of the Wallowa Mountains yields less than 0.1 acre-feet/square mile/year with the exception of a small area on the Grande Ronde River at the Oregon border which yields 0.5 to 1.5 acre-feet/square mile/year. Another localized high yield area is found on the lower Malheur River around Billy Creek reservoir; this area yields 0.2 to 0.5 acre-feet/square mile/year (C.N.P.S., Figures 353 and 418).

b. Ground Water

Aquifers over much of the southern portion of the area have not been tested, but small aquifers which yield up to 500 gallons per minute underlie many of the larger streams. That portion of the area north of the Wallowa Mountains is also largely unexplored, however,

several local aquifers with yields of up to 2000 gallons per minute, and one small aquifer capable of yielding over 2000 gallons per minute, are found adjacent to the Grande Ronde River (C.N.P.S., Figures 356 and 422).

Base flow in the headwaters of the Malheur River is maintained by groundwater discharge from hundreds of small tributaries (C.N.P.S., page 475-476).

Ground water from alluvial deposits in the Owyhee basin generally has less than 300 mg/l dissolved solids from non-irrigated areas, and is hard water with no sodium hazard. Irrigated areas generally have less than 500 mg/l dissolved solids with some sodium hazard. Other aquifers in this basin may have less than 500 mg/l dissolved solids, with the water hard to very hard, and with sodium and flourides sometimes excessive. The alluvial deposits north of the Wallowa Mountains generally yield groundwater with less than 250 mg/l dissolved solids and with no excessive constituents (C.N.P.S., Figures 355 and 421).

5. Closed Basin Area

This area is so-called because streams from the edges of the basin flow toward the center, and there is no outlet for surface runoff from this area. This area is bounded by Steens Mountain on the east, the topographic divide for the Deschutes-John Day Rivers on the north, and the topographic divide for the upper Klamath River on the west. This area includes the Cold Desert over the eastern three-quarters of the area, with the Juniper on Steens Mountain. The western portion of this area is in the Montane Coniferous Forest.

a. Surface Water

The streams on the west side of the area show two annual peaks, one in December, and a second in April or May from snowmelt. These streams are the Chewaucan River which drains into Lake Abert, and Deep and Honey Creeks which drain into the Warner Lakes. The east side streams have only one annual peak, in April or May. These streams are the Silvies River, Cow Creek and the Donner and Blitzen River which drains into Malheur Lake; Silver Creek which drains into Harney Lake; and Trout Creek which drains into Alvord Lake (C.N.P.S., page 509 and Figure 110).

The streams have generally high water quality; essentially they are in a natural condition. The nutrient balance together with the hydrologic regimen produces an ideal ecology for biological productivity and bird habitat (C.N.P.S., page 572). The waters are primarily a calcium-magnesium bicarbonate type, low in dissolved solids and hardness. The lakes into which these streams drain are subject to intense evaporation and the mineral content of these waters may be several hundred times that of the streams. Several of these lakes contain water with a dissolved solids content in excess of 30,000 mg/l. As the mineral concentration increases, certain salts will precipitate out - calcium carbonate and calcium sulfate (gypsum) are the least soluble. The dissolved solids content consists of sodium, bicarbonate, and chloride (C.N.P.S., page 513).

b. Ground Water

This area is underlain by alluvial deposits and rock aquifers which are capable of yielding moderate to large supplies at

many places. The availability of groundwater is limited by the depth to water, which is over 500 feet in many places and over 1000 feet at some locations. The annual recharge rate is small and this places additional limitations on the use of ground water (C.N.P.S., page 510).

Ground water quality is generally poorer than other areas. Dissolved solids are normally less than 1000 mg/l with excessive sodium, boron, and flouride causing problems at some wells. This area contains the greatest concentration of thermal springs of any area in Oregon (C.N.P.S., page 510).

6. Upper Klamath Area

This area is bounded on the west by the crest of the southern end of the Cascade Mountains, the Deschutes River divide on the north, the Closed Basin Area on the east, and the California border on the south. The western quarter of the area as far north as Crater Lake is included in the Broad Schlerophyll and the southern quarter south of Lost River is classified as the Cold Desert. The remainder of the area is forest with the extreme northwest corner in the Northwest Coastal Coniferous Forest, and the rest as the Montane Coniferous Forest.

There are four major river systems in this area. The Sprague River drains into Upper Klamath Lake from the east and has a tributary, the Sycan River which drains Sycan Marsh in the northeast corner of the area. The Williamson River drains Klamath Marsh in the northern part of the area and empties into Upper Klamath Lake. Wood River drains into Agency Lake from the northwestern part of the area;

Agency Lake, in turn, drains into Upper Klamath Lake. The Klamath River originates in Upper Kalamth Lake and crosses the Oregon-California border at the southwest corner of the area. The Lost River drainage forms a small closed basin in the southern part of the area southeast of Klamath Falls. Three of these rivers, the Sycan, Sprague, and Williamson, show a peak flow in April as a result of snowmelt runoff. The hydrograph of the Williamson River below Spring Creek shows the influence of this tributary; Spring Creek is supplied by ground water and this raises the base flow level of the Williamson River to attenuate the snowmelt peak. The Wood River is largely fed by ground water and shows little seasonal variation in flow. The discharge of Lost River is largely controlled for purposes of irrigation. (Klamath Basin, pages 55, 58, and Figures 16, 17, and 18).

Those streams and springs which drain into the Upper Klamath Lake (including the Sprague, Williamson, and Wood River systems) contain water which is generally suitable for most uses. However, iron concentration in Sprague River valley exceeds the allowable maximum (0.3 ppm) for domestic and municipal uses. Turbidity in the lower reaches of the Sprague and Williamson Rivers exceeds the 10 JTU limit which is desirable for fish and other aquatic life during the winter months (Klamath Basin, page 65). The most serious water quality problem in Upper Klamath Lake is a deficiency of dissolved oxygen which is caused by the introduction of phosphates and other chemical nutrients by streams and springs. These nutrients cause algal blooms

which in turn depletes the supply of dissolved oxygen. These algal blooms seriously degrade the water quality of the Klamath River. It should be emphasized that the principal nutrients, phosphates, nitrogen, iron, and various trace elements are supplied by the geologic environment in quantities sufficient to cause the algal bloom. Man's contaminating contributions are minor (Klamath Basin, page 67). The waters which drain into the Upper Klamath Lake are of the calcium-sodium bicarbonate type.

The Lost River basin is the principal source of water for over 200,000 cultivated acres. Therefore, the mineral and nutrient constituents from the geologic material and from irrigation return flows increase downstream to cause progressive degradation of water quality. Dissolved oxygen is deficient in the summer in the lower reaches because of low flows, high temperatures, and massive algal blooms. Alkalinity often exceeds levels desirable for aquatic life. The water varies from a calcium-solium bicarbonate type (probably in the winter high flow period) to a sodium-calcium bicarbonate type (probably in the summer low flow period). Ground water discharge from thermal and alkaline areas is generally too high in total dissolved solids for drinking water or for irrigating sensitive crops. Turbidity has been measured as high as 123 JTU in Lost River in the middle of the basin, well upstream from heavy irrigation use (Klamath Basin, pages 70, 71, and 73).

F. Climate and Air

1. General

The state of Oregon lies mostly between latitudes 42° and 46° North, and extends inland from the Pacific Ocean for some 375 miles. Its area of about 96,700 square miles includes more than 1,000 square miles of water surface. Bordering the Pacific, the Coast Range extends from north to south; its crest is generally at elevations between 1,500 and 2,500 feet. Further to the east, the Cascade Range also lies on a north-south axis, with a summit ridge mostly between 5,000 and 6,000 feet above sea level. Through these mountain ranges, the Columbia River gorge forms a relatively narrow, nearly sea level passage between the Pacific and the intermountain plateau. The Blue and Wallowa mountains are western extensions of the Rocky Mountain system which cover much of the northeastern quarter of the state (Wells, 1941; Sternes, 1966).

This combination of oceanic and continental atmospheric influences and varied topography and land forms gives Oregon a wide range of regional and local climates. Westerly winds from the Pacific predominate; they move large masses of marine air eastward, modifying the climates of the western parts of the state and, to a lesser extent, those of the areas east of the Cascades. The coldest weather in winter and the warmest days of summer occur when these ocean winds cease and the state is blanketed by a mass of continental air (Wells, 1941).

As nearly saturated marine air moves eastward from the Pacific during the colder months, it is cooled both by its contact with the colder ground and by its forced ascent over the Coast and Cascade Ranges. In

these cooling processes large quantities of water vapor are condensed and precipitated as rain or snow on the middle or upper slopes of both mountain ranges. Consequently, the eastward moving air mass is much drier when it reaches the plateau area east of the Cascades than was the original marine air (Sternes, 1966). However, the Columbia River gorge permits some marine air to penetrate the Cascades with more of the oceanic influence than would otherwise occur.

In general, precipitation increases from the coast to the summit of the Coast Range; thence decreases in the valleys of the Willamette, Umpqua and Rogue Rivers; again increases on the west slope of the Cascades; decreases rapidly on the east slope of the Cascades and over the intermountain plateau; and finally increases once more in the Blue Mountains and in the Wallowas (Wells, 1966, p. 1086).

These regional and local variations are very wide. Average annual precipitation ranges from less than 8 inches in the driest parts of the state to more than 130 inches in some localities on the west slope of the Coast Range. Precipitation is seasonal in character, particularly west of the Cascades, where 44 percent occurs in winter, 27 percent in fall, 24 percent in spring, and only 5 percent in summer. East of the Cascades, the corresponding seasonal figures are: winter, 37 percent; fall, 24 percent; spring 27 percent; and summer, 12 percent (ibid.).

Snow seldom falls in coastal areas and when it does, it usually melts very soon. Average annual snowfall ranges from less than one inch

at coastal stations to more than 40 feet at some mountain locations. The mountain snow pack in the Cascades, Blue Mountains and Wallowas is an important source of summer water for irrigation, power and domestic use. Glaciers are located on several of the higher peaks. On the plateau east of the Cascades, much of the winter precipitation is snow, but often the ground is bare for long periods.(ibid.).

Low humidity is normal in eastern Oregon in summer, and east winds occasionally cause very low humidity in western areas. This sometimes occurs even in the winter season. Generally, humidity is high west of the Cascades in winter, and on the coast throughout the year. Normally, humidity is moderately low in eastern Oregon during the winter months (ibid.).

The general eastward movement of marine air masses keeps temperatures moderate most of the time. Infrequently, continental high pressure areas reverse the flow, sending dry air westward, hot in summer and cold in winter (Pacific Northwest River Basins Commission, 1969, p. 49).

The very cold arctic air that forms over Canada in winter is usually barred from the Columbia Basin by the Continental Divide. Occasionally, however, arctic air masses cross the Divide and move southward between the Rocky Mountains and the Cascades. This very cold, dry air then spreads out over the Columbia Basin and the intermountain plateau, causing the more extreme winter temperatures (Sternes, 1966, p. 2). The Columbia River gorge allows continental air to flow into western Oregon from east of the Cascades to a greater extent than it otherwise would. This is particularly true of cold air in winter (Wells, 1941).

Lowest temperatures range from a minimum of -54°F. recorded at Ukiah (Umatilla County) in February to 20° at Gold Beach on the southwest coast. Highest temperature recorded was 119° at Pendleton and Prineville, but coastal stations have registered temperatures exceeding 100°. However, median annual minimum and maximum temperatures are usually well within these extremes. Mean monthly temperatures vary from about 21° (Squaw Butte, Harney County) and 46° (Curry County coast) in January, to 56° (crest of the Cascades) and 78° (Snake River valley and Columbia River valley areas east of the Cascades) in July (Climate and Man, pp. 1075-1079). The average length of growing season (period between last killing frost in spring and first killing frost in fall) ranges from more than 280 days on portions of the Curry County coast to as little as 79 days on the high desert at Blitzen (Harney County) and the northern edge of the Great Basin at Silver Lake (Lake County). Some of the high plateau areas have less than 50 growing days, and there are locales where frost may occur in any month (ibid., pp. 1075-1086).

During the winter months, coastal southerly and southwesterly winds originating in Pacific low-pressure systems may become very strong, occasionally developing hurricane force. These winds move inland a few times each winter and are sometimes destructive (ibid., p. 1086; Decker, 1961, p. 18).

Thunderstorms are rare in the western valleys, more frequent in the eastern valleys and over the intermountain plateau, and rather common in the Cascades, Blue Mountains and Wallowas, where many forest

fires are caused by lightning (Wells, p. 1086). Hailstorms occur each year, but are generally light and local. The overall damage they cause is insignificant (Sternes, 1967, p. 3).

Most of Oregon experiences ample sunshine in summer, but there is much cloudiness during the late fall, winter and early spring months. This is particularly true west of the Cascades. The city of Baker averages more than 2,700 hours of sunshine annually. Portland has an annual average of less than 2,120 hours of sunshine; coastal points average less than 2,000 hours (Wells, p. 1086).

Three major factors determine the distribution and composition of plant communities; these factors are climate, soil and time. Climate, which is primarily an expression of moisture and temperature conditions, is of first importance (Van Dersal, 1938, pp. 17, 18). Because of the wide range of climatic conditions within the state of Oregon, there are significant differences between the climates of the six sub-biomes considered in this statement. These climatic variables have largely determined the character and distribution of the vegetation found in each of the sub-biomes.

2. Northwest Coastal Forest

This sub-biome is characterized by heavy precipitation during late fall, winter and spring. Moist winds from the Pacific have given rise to the forests between the coast and the summit of the Cascades (Zon, 1941, p. 493). July and August are generally the driest months, December and January the wettest (see Figures 13 + 14).

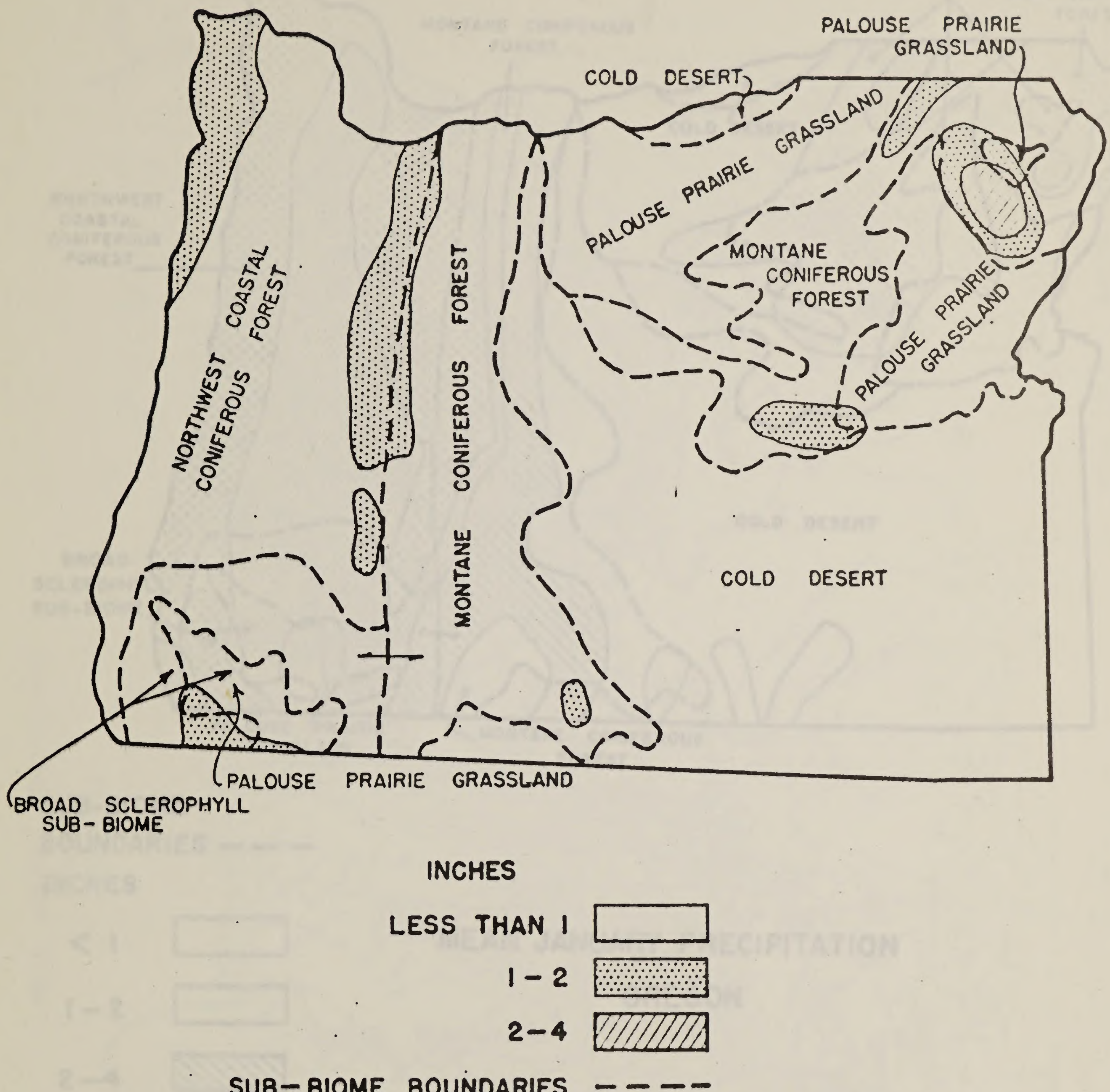
Average annual precipitation ranges from about 29 inches in the middle Umpqua River drainage to more than 120 inches at some locales in the Coast and Cascade Ranges (Figure 15). More than two-thirds of the annual precipitation falls during the period from October 1 to March 31.

Lowest temperatures have varied from less than -20° F. at McMinnville and some locations on the upper west slopes of the Cascades to 20° on the Curry County coast. High temperatures can exceed 100° anywhere in the sub-biome; highs of 110° and more thave been recorded in the Cascades and some interior valley locations. Even some coastal points have experienced temperatures of more than 100°, but this is rare. Mean monthly temperatures range from about 30° (crest of the Cascades) and 46° (Curry County coast) in midwinter, to 56° (crest of the Cascades) and 68° (interior valleys) in July. The length of growing season varies from more than 280 days at some locations on the Curry County coast to less than 120 days at some points in the Cascades (Figure 16).

This sub-biome is periodically exposed to strong south and southwest winds moving inland from the Pacific, sometimes with very great force. While these are primarily winter occurences, the most destructive windstorm of recent history happended in October. Thunderstorms are infrequent, except along the upper slopes of the Cascades.

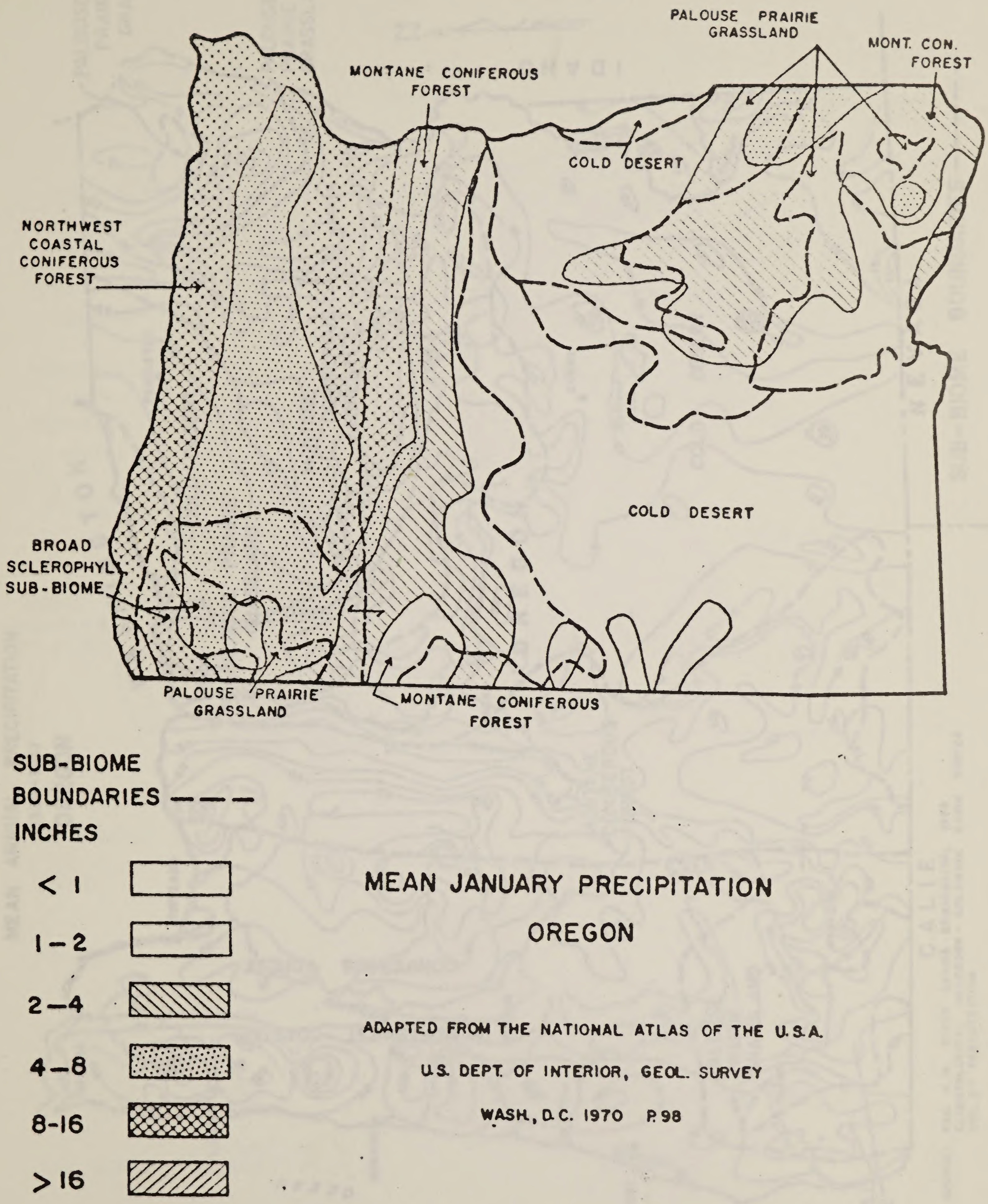
3. Montane Forest

Elevation is a major climatic influence in this sub-biome; the higher the elevation, the colder and wetter the climate. There is



– MEAN JULY PRECIPITATION – OREGON

ADAPTED FROM : THE NATIONAL ATLAS OF THE U.S.A.
U.S. DEPT. OF INTERIOR, GEOL. SURVEY
WASH., D.C. 1970. P. 99



MEAN JANUARY PRECIPITATION

OREGON

ADAPTED FROM THE NATIONAL ATLAS OF THE U.S.A.

U.S. DEPT. OF INTERIOR, GEOL. SURVEY

WASH., D.C. 1970 P. 98

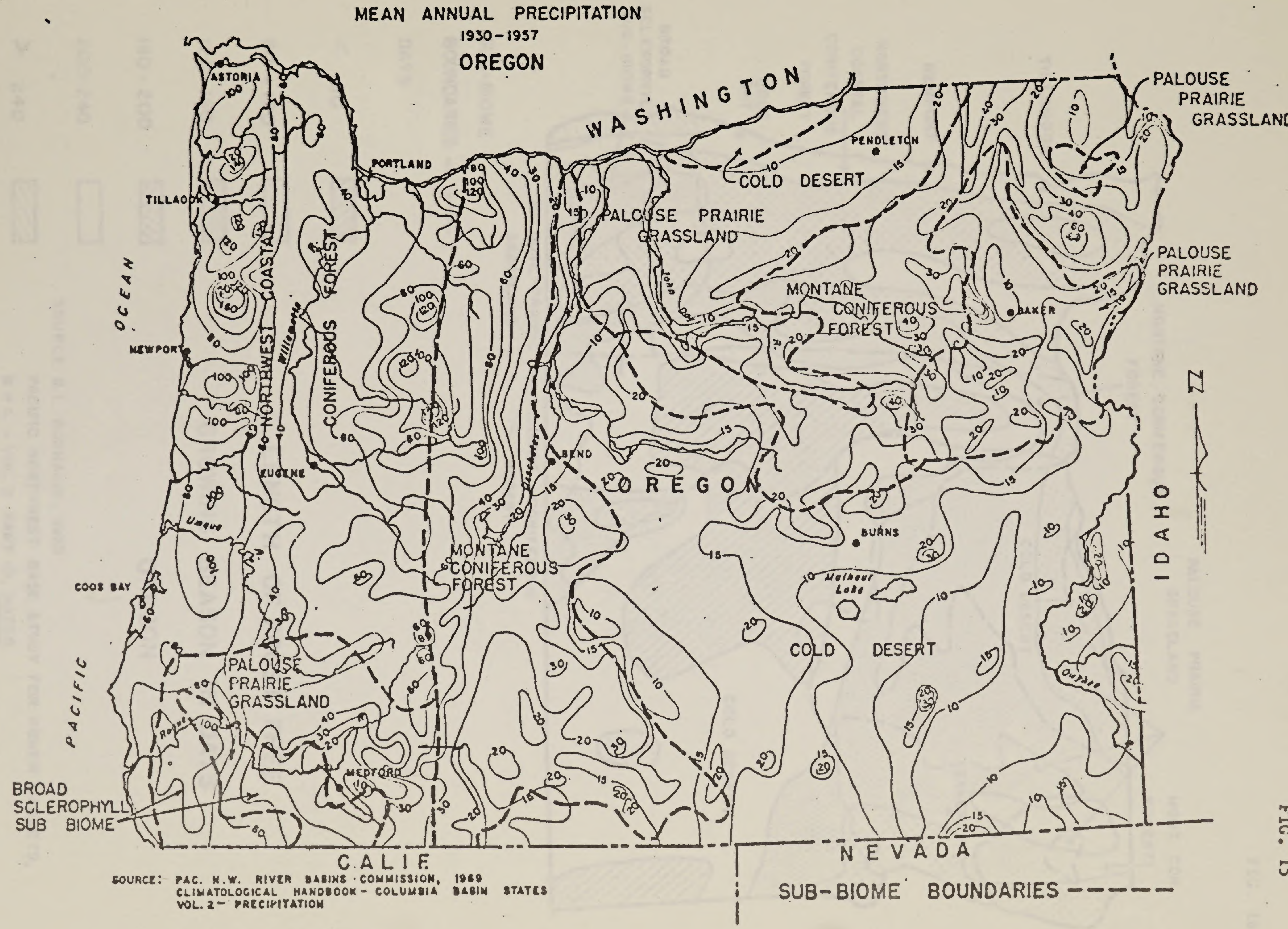
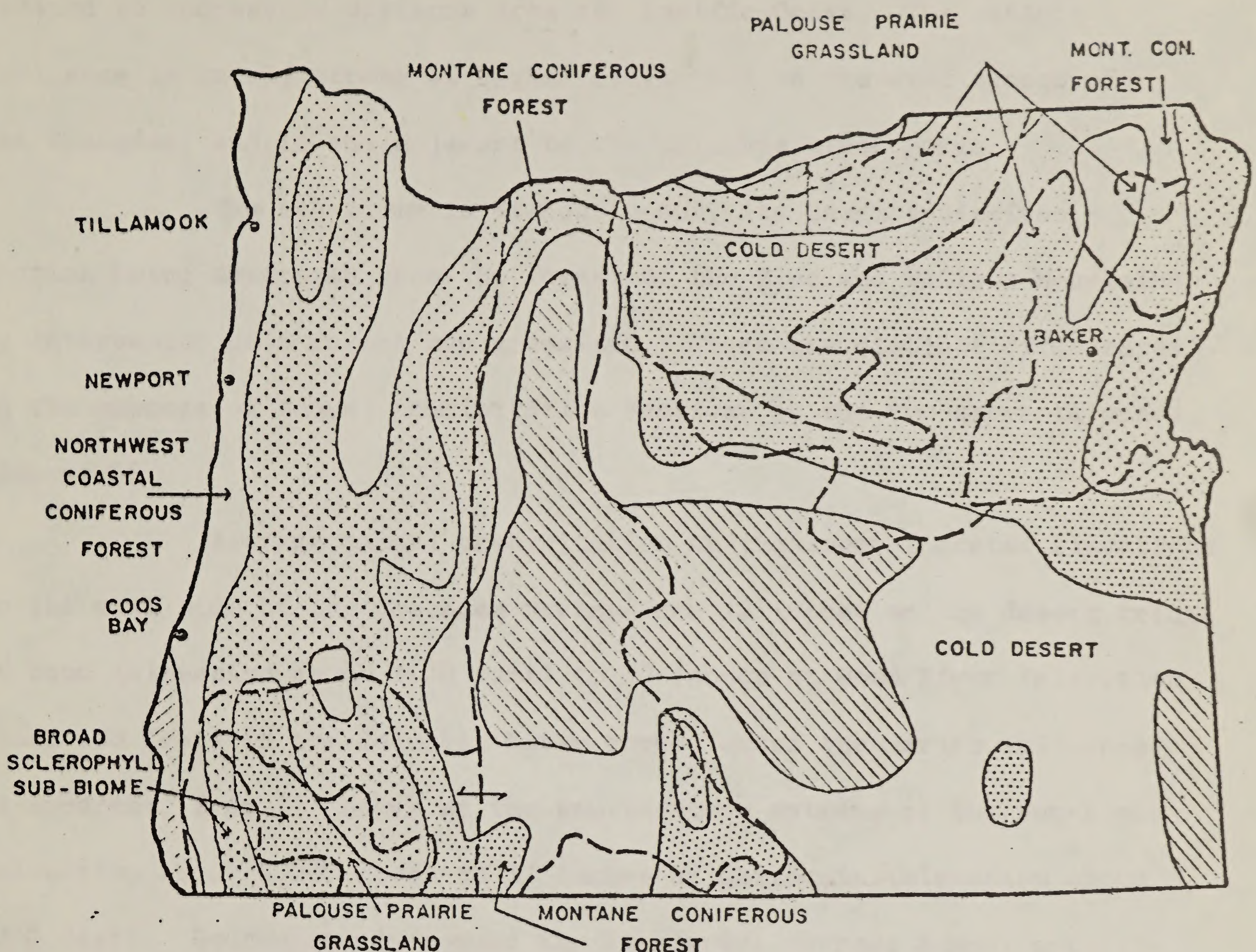

MEAN ANNUAL PRECIPITATION
1930–1957
OREGON
WASHINGTON
PALOUSE PRAIRIE GRASSLAND
ASTORIA
PORTLAND
TILLAMOOK
PENDLETON
COLD DESERT
PALOUSE PRAIRIE GRASSLAND
PALOUSE PRAIRIE GRASSLAND
OCEAN
NORTHWEST COASTAL CONIFEROUS FOREST
MONTANE CONIFEROUS FOREST
BAKER
NEWPORT
BEND
EUGENE
OREGON
IDAHO
N
BURNS
Umpqua
MONTANE CONIFEROUS FOREST
COOS BAY
Malheur Lake
COLD DESERT
PACIFIC
PALOUSE PRAIRIE GRASSLAND
Owyhee
MEDFORD
BROAD SCLEROPHYLL SUB BIOME
C.A.L.I.F.
NEVADA
SOURCE: PAC. N.W. RIVER BASINS COMMISSION, 1969
CLIMATOLOGICAL HANDBOOK - COLUMBIA BASIN STATES
VOL. 2 - PRECIPITATION
SUB-BIOME BOUNDARIES

FIG. 15

FIG. 16



SUB-BIOME BOUNDARIES — — —

DAYS

< 80

80 - 120

120 - 160

160 - 200

200-240

> 240

LENGTH OF FROST FREE GROWING SEASON IN DAYS OREGON

SOURCE: G. L. BODHAINE, 1963
PACIFIC NORTHWEST BASE STUDY FOR POWER MARKETS, B. P. A. - VOL. 2 PART 10, WATER
DATA FROM U. S. DEPT. OF AGRICULTURE

also a general decrease in precipitation from west to east, which is related to increasing distance from the Pacific Ocean. The oceanic influence is fairly strong at higher elevations on the east slopes of the Cascades, and in and adjacent to the Columbia River gorge.

The sub-biome is discontinuous, its Cascade-Siskiyou portion being separated from the forest of the Blue and Wallowa Mountains by intervening cold desert and grassland. There are distinct differences in the amounts of annual precipitation received by the two separate areas. (Figure 15).

Average annual precipitation at the lower forested elevations on the east side of the Cascades varies from 12 inches on the desert fringe at Bend (elevation about 3600 feet) to 30 inches at Hood River (elevation about 150 feet) in the Columbia River gorge, where the marine influence is apparent, from 15 inches at the southeastern extreme of the sub-biome (elevation about 5,000 feet) to 17 inches at Chiloquin (elevation about 4200 feet). Southwesterly toward the Siskiyous, average annual precipitation increases with proximity to the Pacific. At the lower elevations on the fringes of the Palouse Prairie Sub-biome in the Rogue River valley, annual precipitation ranges from about 20 inches in the east to 32 inches in the west. Average annual precipitation at the higher elevations varies from 32 inches at Siskiyou Summit (4467 feet) to more than 120 inches at some locations along the crest of the Cascades.

To the east, in the Blue and Wallowa Mountains and Ochoco highlands, average annual precipitation exceeds 48 inches only at the higher elevations. A small area in the Wallowas (above 9,000 feet elevation)

receives more than 60 inches. Generally, much of the forested area in northeastern Oregon receives less than 24 inches of precipitation annually.

Average January precipitation varies from more than 10 inches along the upper east slopes of the Cascades to about 5 inches in the Columbia gorge near Hood River, decreasing southward at the lower forested elevations to about 2 inches. In the Siskiyou area, Grants Pass and Siskiyou Summit receive about 6 inches of precipitation in January, Ashland less than 3 inches. The Blue Mountain - Wallowa Mountain region averages more than 4 inches at the higher elevations, less than 2 inches at the lower locations in January. In this sub-biome, nearly all winter precipitation at the higher elevations occurs as snowfall.

In July, the average precipitation on the upper slopes of the Cascades is 1 to 2 inches, less than 1 inch at lower elevations there and in the Siskiyous. July precipitation through the Blue Mountain and Wallowa Mountain area generally averages less than one inch, although this may be exceeded at highest elevations.

Average temperatures during January range from about 33° at the lower elevations (Hood River) to 25° (Crater Lake) and 23° (Ukiah, Umatilla County). Mean July temperatures vary from about 57° (upper slopes of the Cascades and 62° (higher elevations in the Blue and Wallowa Mountains) to about 70° in the Columbia River gorge. Maximum length of average growing season is about 200 days in the Columbia River gorge and 120-130 days at the lower forested elevations on the intermountain plateau. Minimum length of the frost-free period can be only a few days at highest

points in the Cascades and Wallowas, but generally the upper areas of the sub-biome have a growing season of about 60 days, (Figure 16).

Wind directions and velocities are influenced by topography. There is considerable convective activity, especially during the summer months. At the summits of the mountain ranges, winds are generally from the west and are frequently very strong in winter and spring.

Thunderstorms are frequent in portions of the sub-biome, particularly in the Wallowas and in the Blue Mountains. Usually occurring during the warm, dry months of summer, these storms are accompanied by lightning activity which sometimes ignites fires in inaccessible forested areas, thus causing protection problems.

4. <u>Palouse Prairie Grassland</u>

Climatically, this sub-biome differs from the major grasslands east of the Continental Divide, which characteristically receive most of their precipitation during the summer. On the Palouse Prairie, grasses grow during the wet spring season and are mature and dry by July 1. A long frost period during winter, and the dry summer season, force vegetation to remain dormant most of the year. Only during the spring, when temperatures above freezing coincide with adequate soil moisture, can the comparatively shallow-rooted grasses grow (Stoddart and Smith, 1955, pp. 58, 59).

Throughout most of the sub-biome, average annual precipitation ranges from about 10 inches at lower elevations and locations bordering the Cold Desert to more than 20 inches at higher elevations on the fringes of the <u>Montane Coniferous Forest.</u> That isolated portion

of the grassland located in southwestern Oregon is somewhat wetter, some locations receiving more than 30 inches of precipitation annually (Figure 15). Mean January precipitation varies from less than one inch at Enterprise and Baker to about 6 inches in parts of the southwestern Oregon portion of the sub-biome. July precipitation averages much less than one inch throughout the biome (Figure

Average monthly temperatures for January range from about 39° in the southwestern Oregon portion of the sub-biome to about 23° in the Wallowa County grassland at Enterprise. Mean July temperatures vary from about 63° in the latter location to as high as 80° in the southeastern extreme of the sub-biome, where it adjoins the Snake River. Length of average growing season is as much as 190 days at Milton-Freewater (Umatilla County) and 182 days in the Snake and Rogue River valleys. The growing season can be as brief as 120 days in the north central portion of the sub-biome at Condon and 132 days in the upper John Day River valley at Dayville. (Figure 16).

Much of the original grass cover in this sub-biome has been disturbed or destroyed by cultivation. As a result, extensive dust storms occasionally occur when winds blow strongly during periods of drought, when the topsoil is dry.

5. <u>Cold Desert</u>

Aridity is characteristic of this sub-biome. Its southeastern portion includes the driest parts of Oregon, some of which receive less than 8 inches of precipitation annually (Figure 15).

Average annual precipitation varies from about 7 inches at two recording stations to about 14 inches at some locations near the fringe of the Montane Coniferous Forest. A range of 9-12 inches is typical. Some areas usually receive less than 1 inch of precipitation in January, while average precipitation for that month may exceed 2 inches at other points. Average July precipitation ranges from a slight trace to more than 1/3 inch. Very low humidity is a normal summer condition.

Mean January temperatures vary from about 21° to about 33°. The latter average temperature is typical of that portion of the sub-biome which adjoins the Columbia River, where elevations generally are less than 1,000 feet. Most of the Cold Desert experiences January mean temperatures below 31° and above 24°. July temperatures average about 63° at the higher elevations and as much as 76° at the low levels along the Columbia River. On the high desert (elevations above 4,000 feet), hot days and cool nights are characteristic of the summer season.

Maximum length of growing season is more than 200 days at low elevations along the Columbia River. Minimum growing seasons occur at highest points on the southeastern Oregon plateau, where the frost-free period may be less than 50 days. The average growing season over most of the sub-biome ranges from about 90 to 140 days. The southeastern portion of the Cold Desert experiences more hours of sunshine annually than other Oregon locations.

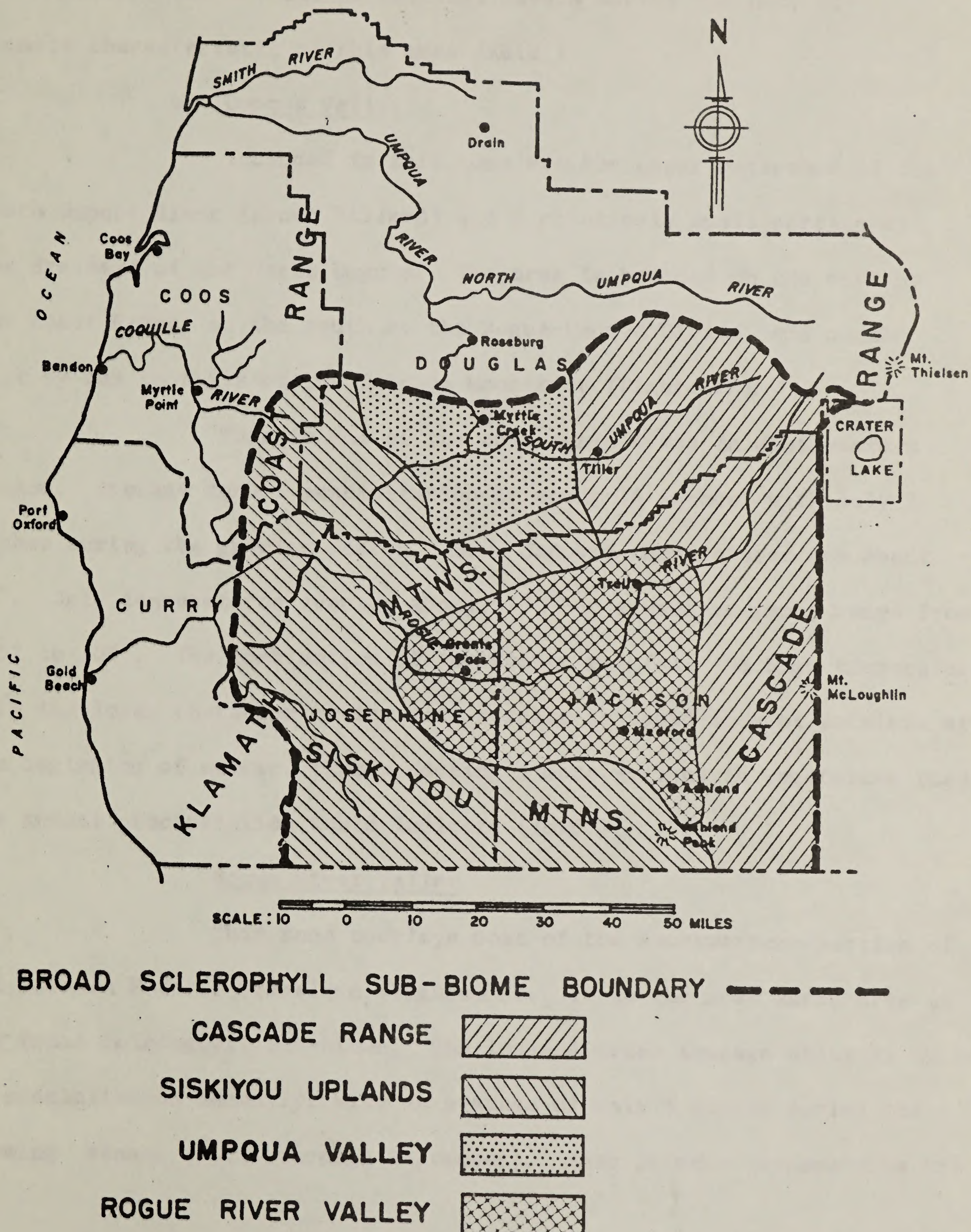
6. Broad Sclerophyll

This plant association overlays the southwest Oregon portions of the Montane Coniferous Forest and the Palouse Prairie Grassland. Its climates coincide with the local climates of those portions of the other two sub-biomes which lie within the Broad Sclerophyll range. Although these climates are variable, they are generally characterized by xeric conditions during the summer; i.e., total precipitation during the fall, winter and spring months may be moderate to heavy, but summers tend to be dry and hot (Gratkowski, 1961, pp. 18-28). Following are descriptions of the local climates within the Broad Sclerophyll Sub-biome, zone by zone.

a. Siskiyou Uplands.

This zone includes the Siskiyou Mountains and that portion of the Coast Range east of the summit and south of the Coquille River. It is bounded by the Northwest Coastal Coniferous Forest Sub-biome on the west and by the Rogue and Umpqua River valleys on the east (Figure 17).

Climatic conditions vary considerably. A long, dry season with high summer temperatures is characteristic of the area. However, the western part of the zone (adjoining the Northwest Coastal Coniferous Forest) has an average annual precipitation of 90 to 100 inches, average January temperatures of about 42°, and 14 to 16 inches of rainfall during the growing season. Eastward, the climate becomes progressively drier. At the east end of the Siskiyou Mountains, average annual precipitation is about 25 to 30 inches, with only about 4 inches of rainfall during



—CLIMATIC ZONES OF THE BROAD SCLEROPHYLL SUB-BIOME

SOURCE : H. GRATKOWSKI , 1961
BRUSH PROBLEMS IN SOUTHWESTERN OREGON
U.S. FOREST SERVICE – PAC. N.W. FOREST
& RANGE EXPM. STA.

the growing season, and average January temperatures are 30° to 32°. Soil moisture can decline to critical levels during the hot, dry summers characteristic of this area (ibid.).

b. Umpqua Valley.

Included in this zone are the upper watershed of the South Umpqua River (above Dillard) and a relatively small portion of the drainage of the North Umpqua. The area is bounded on the west by the Coast Range, on the south by the Rogue-Umpqua Divide, and on the east by the foothils of the Cascade Mountains (Figure 17).

This is one of the most xeric areas in southwestern Oregon. Average annual precipitation is about 34 inches, with only 7 inches during the growing season. Mean January temperatures are about 41°. July temperatures average about 67°, but summer maximums range from 105° to 108°. The combination of low summer rainfall and high temperatures with the loose character of the soil results in rapid loss of moisture at the beginning of summer, thus producing a more xerophytic vegetation than the annual precipitation would indicate (ibid.).

c. Rogue River Valley

This zone overlays most of the southwestern portion of the Palouse Prairie Grassland (Figure 17). It is the most xeric area in the Broad Sclerophyll Sub-biome. The lowland areas average about 22 inches of precipitation annually, with an average of only 5 inches during the growing season (April through September). Mean January temperatures are

fairly low (about 38°), but the July average is 70°, highest in the subbiome. High summer temperatures are characteristic; maximums of 110° have been recorded. Climatic conditions in the western part of the valley at Grants Pass are similar to those in the Umpqua Valley. The zeric condition is most pronounced to the east, around Medford, where average annual precipitation is less than 20 inches (ibid.).

d. Cascade Range.

Located on the western slope of the Cascade Mountains, this zone extends southward to the California border. Its eastern boundary is the crest of the Cascade Range. Its northern extreme is generally the divide between the North and South Umpqua Rivers. To the west, it adjoins the Umpqua and Rogue River Valleys and Siskiyou Uplands (Figure 17).

Variations in elevation within this zone are striking. Most of the area lies above an elevation of 1,500 feet; the general level of the crest of the southern Cascades is about 6,000 feet, but peaks rise to more than 9,000 feet. A large, relatively level plateau to the west of the Cascade summit occupies much of the zone. This plateau ranges from about 2,500 to 5,300 feet in elevation.

Climatic conditions within the zone vary considerably with these differences in elevation. Generally, with increasing elevation, precipitation increases while temperature and length of frost-free season decrease. The southern portion of the zone, in the lee of the Siskiyous, is much drier than the area farther north. The southern area averages only about 19 inches of precipitation, and receives only 6 to 8 inches of rainfall during the growing season. Average annual precipitation in the northern

portion ranges from 40 to 60 inches, with 8 to 12 inches falling during the growing season (ibid.).

7. Juniper

This sub-biome is the most xeric of the tree-dominated zones in the Pacific Northwest. The Juniper sub-biome, like the Broad Sclerophyll, overlays portions of a larger sub-biome, in this case the Cold Desert. It generally occupies habitats which are intermediate in moisture between the ponderosa pine sites on the fringes of the Montane Coniferous Forest, and the shrub communities which are typical of much of the Cold Desert (Franklin and Dyrness, 1969, pp. 105-110). The Juniper sub-biome reaches its maximum development in central Oregon around the Deschutes, Crooked and John Day Rivers (ibid.), at elevations between 2,900 and 4,000 feet, in an area which receives 8 to 12 inches of average annual precipitation (ibid.).1/

Elevational range of the Juniper sub-biome throughout its distribution appears to be from about 2,500 to 4,600 feet; the center of the juniper zone typically receives 8 to 10 inches of precipitation annually. Most precipitation falls during the winter, and the hot summer months are often completely dry (ibid.).1/ These climatic conditions are characteristic of the general climate of the Cold Desert. However, there may be unmeasured micro-climatic variables which have determined the distribution of juniper stands throughout the desert. Some of these variables may be related to the moisture retention capacity of soils.

1/ Metric units in cited reference have been converted to English units.

One researcher has suggested that the uniper zone be divided into three units on the basis of soil characteristics (Driscoll, 1964).

G. Vegetation

1. Terrestrial Vegetation

Terrestrial vegetation of Oregon varies extensively depending upon geographic location, elevation and other environmental conditions. Generally speaking, the western one-third of the state (from the eastern foothills of the Cascade Mountains to the Pacific Ocean) is dominated by coniferous forest interrupted by the Willamette, Umpqua and Rogue River Valleys. The eastern two-thirds, however, is a mosaic of conifer, brushland, or grass dominated vegetative cover.

The following description deals only with major non-agricultural vegetative conditions such as forest zones, wherein a single tree species is the major climax dominant (Franklin & Dyrness 1969, p. 37), or vegetative types of other kinds. Each forest zone or vegetative type described has within its boundary other kinds of undescribed (in this statement) vegetation limited to a very small proportion of the total land area. Oak (Quercus) - grass types scattered throughout the coniferous forest is one example. Another is Riparian, or streamside, vegetation which forms a network throughout all sub-biomes. Riparian vegetation varies considerably and may include red alder (Aluris rubra), black cottonwood (Populus trichocarpa), and where annual flooding occurs, willow (Salix spp.). Where streams are normally confined to their banks such vegetation is more typical of the forest zone, or other vegetative type, within which it lies.

a. Palouse Prairie Grassland

The Grassland is the most extensive and varied of all the biomes in the United States. It consists of five distinctive, widely spread sub-biomes. These are the North Temperate Grassland, South Temperate Grassland, Palouse Prairie, California Prairie and the Coastal Prairie.

Of these, only a portion of the Palouse Prairie exists in Oregon. It covers approximately the northeast quarter of the state with the exception of the Blue Mountains and an area in southwestern Oregon in portions of Jackson, Josephine and Douglas counties. Refer to Figure 6 .

Predominant vegetation consists of a large selection of grass species occurring in both a natural state and in extensive areas under cultivation. Sagebrush and other shrub species are interspersed with the grasslands throughout much of the area.

Precipitation in the Palouse Prairie is low, ranging from about 10 to 20 inches. Most of this falls from early September to early April in the form of snow. Growth occurs mainly during the early spring months and the grasses mature and dry by the first of July. A long frost period during the winter and a dry summer period force vegetation to remain dormant the greater part of the year. Fall growth occurs only in unusually favorable years.

Clearly the most important native grasses of the Palouse Prairie are the bluebunch wheatgrass (Agropyron spicatum)

and its close relative Agropyron inerme. Idaho fescue (Festuca idahoensis), needlegrass (Stipa comata), Sandbert bluegrass (Poa secunda), Junegrass (Koeleria cristata), and big bluegrass (Poa ampla) are the associated grasses. Bottomlands and clay soils are often dominated by giant ryegrass (Elymus cinereus) and western wheatgrass (Agropyron smithii). Sandy soils and rocky soils may support Indian ricegrass (Oryzopsis hymenoides), needlegrass (Stipa comata), and sand dropseed (Sporobolus cryptandrus). Annual bromes, downy bromegrass (Biomus tectorum) and others have invaded the northeastern Oregon area almost everywhere as a result of fire and heavy grazing. In southwestern Oregon medusahead wildrye (Elymus caput-medusae) is the principal invader and now occupies approximately 70-80 percent of the area. As a result of bunch wheatgrass can only be found in the more isolated undisturbed areas.

Interspersed with the grasses are various shrub species. Major shrubs are big sagebrush (Artemisia tridentata var. tridenta) with lesser amounts of rabbitbrush (Chrysothamnus spp.). Three tip sage (Artemesia tripartita), and hopsage (Grayia spinosa) may also be present. On the more rocky or shallow soil areas bitterbrush (Purshia tridentata) may be intermixed with the grasses while on sandy sites bitterbrush and rabbitbrush are found. In southwestern Oregon additional shrub species may be intermingled with the various grass species. These are western juniper (Juniperus occidentalis), wedgeleaf (Ceanothus cuneatus) black and white oak (Quercus spp.).

Only in the more moist borderlands are broad leaved herbs important. Balsamroot (Balsamorhiza spp.), lupine (Lupinus spp.), yarrow (Achillea spp.), mule-ear dock (Wyethia spp.), and little sunflower (Helianthella spp.) are locally abundant.

Plant species that are uncommon or rare are red three-awn (Aristida Longiseta), shadscale saltbush (Atriplex Confertifolia), Snake River greasebush (Forsellesia Stipulifera) and poets shooting star (Dodecatheon Poeticum).

Successional changes are most often associated with grazing, fire, cultivation and other disturbances. Grazing most seriously affects the larger perennial grasses since they are preferred by cattle and sheep. Heavy grazing therefore tends to eliminate Agropyron spicatum, Festuca idahoensis, etc., and to increase sagebrush and annual grasses, particularly Bromus tectorum in the northeastern, and Medusahead-rye in the southwestern area.

b. <u>Cold Desert</u>

The <u>Cold Desert</u> sub-biome occupies most of the great basin area. It extends into Oregon covering approximately the southeast quarter of the state. Often referred to as the high desert, it is typified by irregular topography and generally shallow rocky soils, many with little profile development.

Precipitation occurs during the non-growing season and the summers are hot and dry. As a result vegetation is deep rooted or matures before summer droughts begin. Temperatures are low during the winter months; therefore, growth is confined to a brief spring period.

Shrubs generally dominate the various plant communities. Approximately 80-85 percent of the range land is dominated by big sagebrush (Artemisia tridentata) with the remainder dominated by other shrubs such as rabbitbrush (Chrysothamnus spp.) bitterbrush (Purshia tridenta), hopsage (Grayia spinosa) and shadscale (Atriplex confertifolia).

Shrub-types other than those dominated by sagebrush characteristically occupy the foothills, plateau and more alkaline lowlands. Interspersed throughout the rangeland communities, particularly in the higher elevations and forest fringe areas, are scattered stands of western juniper (Juniperus occidentalis).

The most important species making up the grass understory consist of bluebunch wheatgrass (Agropyron spicatum) squirreltail (Sitanion hystrix) Idaho fescue (Festuca idahoensis) sandberg bluegrass (Poa secunda) needlegrass (Stipa spp.) and cheatgrass (Bromies tectorum). Cheatgrass is an early maturing annual ideally suited to grow in a dry habitat. It is an invader particularly abundant in areas that have been disturbed by heavy grazing, fire or other causes.

In some areas where soil and moisture conditions are favorable, portions of the native range have been artificially treated to increase forage production. Sagebrush has been killed generally by spraying to eliminate competition with the native grasses.

Often areas have been plowed and seeded primarily with crested wheatgrass (Agropyron cristatum).

Forbs occur with the grass understory throughout the area. Some of the more important include phlox (Phlox spp.)

mountain dandelion (Agoseris spp.) hawksbeard (Crepis spp.) lupine (Lupinus spp.) and larkspur (Delphinium spp.). On the more moist foothill zones balsomroot (Balsomorhiza spp.) mulesears (Wyethia amplexicaulis) aster (Aster spp.) and milkvetch (Astragalus spp.) may be found. Tumblemustard (Sisymbrium altissimum) is a common invading species and Russian thistle is abundant in areas under recurrent disturbance. Halogeton (Hologeton glomeratus) is invading disturbed areas in the extreme south part of the area adjacent to the Nevada state line.

Areas occupied by big sagebrush differ in grazing use from shadscale areas. The sagebrush is essentially a spring-fall range and the shadscale a winter range. Sagebrush is the more productive of the two and thrifty growth of this plant indicates deep soil and better moisture conditions.

In the cold desert biome there are widely distributed and isolated botanic islands of unusual floristic composition generally the result of unusual or unique geologic phenomena. The recent Jordan Lava Flow is a basic extrusion of perhaps two to four thousand years of age and forms a habitat for unusual vegetation. Deep cracks occasionally support fern species some of which have been tentatively identified as Dryopteris, Polypodium and Lomeria. Species of dwarf Penstemon are also present. Perhaps unique is the occurrence of Pediocactus species in the Alvord Desert. This species is believed to be undescribed to science.

The vegetation complex of the Steens Mountain includes a vast variation in species composition and species association. The vegetative life zones are numerous as you ascent the mountain and as elevational differences occur. Part of the mountain falls within the Juniper sub-biome. Some species occur frequently while others are extremely rare. There are seven species that are found only on the Steens Mountain and some that are found only on this and one or two other mountains. The seven endemic species, as identified by Goodman Hansen of Oregon State University, include Agastache cusickii, Allium punctatum, Castilleja steenensis, Cirsium peckii, Draba cruciata, and Lupinus lyalli. Cirsium pickii is widespread in its distribution over the mountain while the remainder are fairly localized but not necessarily uncommon.

c. Juniper

Scattered stands of juniper are present throughout the southeast quarter of the state, generally within the same boundary as the Cold Desert. These small trees form a scattered overstory, giving a characteristic woodland aspect. Juniper occurs at intermediate elevations in areas where precipitation may be as low as 8 inches, as well as where it averages 16 inches on the fringe of the ponderosa pine belt.

In Oregon, juniper seems close to sagebrush in its ecological requirements, the two being sometimes mixed and sometimes separated. Sagebrush usually occurs on the moister, deeper soils and juniper on the drier, rocky, or more alkaline low-producing sites.

In some areas few desirable forage plants remain and there is high erosion susceptibility.

Juniper seems to be invading adjacent brush and grass types due to decreased fires and increased grazing use. The trend is still evident and expected to continue until surface management practices come into balance with climatic, site, and environmental factors. In some areas juniper chaining is being done to eliminate competition with plants more desirable for domestic livestock forage, wildlife habitat and watershed protection.

The major juniper species in Oregon is Western juniper (Juniperus occidentalis) with big sagebrush (Artemisia tridenta) most often the dominant understory shrub. Occasionally sagebrush is either intermixed with or displaced by bitterbrush (Purshia tridentata). Other associated shrubs are rabbitbrush (Chrysothamnus nauseosus and Chrysothamnus viscidiflorus), horsebrush (Tetradymia canescens), gilia (Leptodactylon pungens), and lowsage (Artemisia arbuscula). Occasionally wild gooseberry (Ribies spp.) and hopsage (Grayia spinosa) can be found.

Characteristic grasses of relatively undisturbed communities are blue bunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis), sandberg bluegrass (Poa secunda), and needlegrass (Stipa thurberiana). Other grasses include squirreltail (Sitanion hystrix) cheatgrass (Bromus tectorum), six week fescue (Festuca octoflora), and junegrass (Koeleria cristata).

Some of the more common associated forbs are mountain dandelion (Agoseris spp.), common yarrow (Archillea millefolium), milkvetch (Astragalus spp.) wild daisy (Erigeron linearis) and lupine (Lupinus spp.).

Although some juniper types have little remaining forage most are important spring and fall ranges for domestic livestock and spring winter range for deer. They are also important recreation and open space areas. Some local residents harvest the juniper for cord wood and fence posts. Some juniper is also utilized in the production of novelty items; e.g., wood carvings, bowls, table lamps.

d. Broad Sclerophyll

This sub-biome exists as scattered or interrupted areas in southwestern Oregon (See Figure 6) where sclerophyllus species (species with broad, evergreen leaves) are predominate in a climax association; i.e., the final stage of plant succession. Such climax communities normally occur on the dryer (xeric) sites typical of the Umpqua or Rogue River Valley and shallow soils on southerly exposures at higher elevations or areas of high rainfall (Franklin and Dyrness 1969, pp. 80-103).

Vegetation common to the sub-biome may include the following broadleaf evergreen trees and shrubs (typical sclerophylls) and deciduous species to a lesser degree (Franklin and Dyrness, ibid):

Evergreen (Sclerophylls)	Deciduous
Tanoak (Lithocarpus densiflorus)	Oregon White Oak (Quercus garryana)
Chinkapin (Castanopsis chrysophylla)	California Black Oak (Q. Kelloggii)
Canyon Live Oak (Quercus chrysolepis)	Redstem Ceanothus (Ceanothus sanguineus)
Pacific Madrone (Arbutus menziesii)	Deerbrush Ceanothus (C. integerrimus)
Narrow-leaf Buckthorn (Ceanothus cuneatus)	Pale Serviceberry (Amelanchier pallida)
Snowbrush or Varnishleaf (C. veluntinus)	Skunkbrush sumas (Rhus trilobata)
Pine Mat Manzinata (Arctostophylos nevadensis)	Poison Oak (Rhus diversilobah)
Hoary Manzanita (A. canescens)	
White Leaved Manzanita (A. viscida)	
California Coffee Berry (Rhamnus californiaca)	
Birchlead Mountainmahogany (Cereocarpus betuloides)	

Vegetation typical of the Broad Sclerophyll frequently occurs outside the sub-biome as an intermediate stage of plant succession where a later stage will be coniferous forest: such an area is however considered as the Montane Coniferous Forest rather than Broad Sclerophyll. It is often very difficult to determine whether a community on a given site is climax or intermediate (seral).

e. Northwest Coastal Forest

This is the most densely forested of the two coniferous forest sub-biomes. Forests of this sub-biome generally regenerate easily and quickly, grow rapidly and reach impressive sizes. Forests with open canopies usually have lush understory, shrub, and herbaceous

layers comprised of shade tolerant conifers, shrubs, ferns, other herbs, mosses and liverworts. Forests with closed canopies, however, generally have poorly developed lower layers.

Plant succession in the Northwest Coastal Forest, following removal of forest vegetation, usually proceeds through three stages; (1) rapid growth of residual and invading herbaceous plants (such as grasses and ferns), (2) gradual development into a shrub dominated condition, and (3) development of the young growth forest. Stages one or two, or both, may not occur depending upon environmental factors. Either of the first two stages may also dominate for exceedingly long periods of time, also due to environmental factors.

Franklin and Dyrness (1969) have identified five major vegetative (climax) zones within the sub-biome that are dominated by coniferous vegetation; they include (1) the coastal "Sitka Spruce Zone", (2) the widespread inland low to mid-elevational "Western Hemlock Zone", (3) the higher elevational "Pacific Silver Fir Zone", (4) the sub-alpine "Mountain Hemlock Zone" and (5) "Timberline". (See Figure 18) These vegetation zones reflect climatic conditions inherent with elevational differences that occur throughout the Northwest Coastal area. The "Sitka Spruce Zone" where snow seldom occurs, for example, is the mildest in Oregon, while the "Mountain Hemlock Zone" is one of the coldest; annual snowpacks commonly attain depths up to 20 feet or more.

Major tree species found within the Northwest Coastal Forest and their occurrence within the major zones are estimated in Table I.

TABLE I

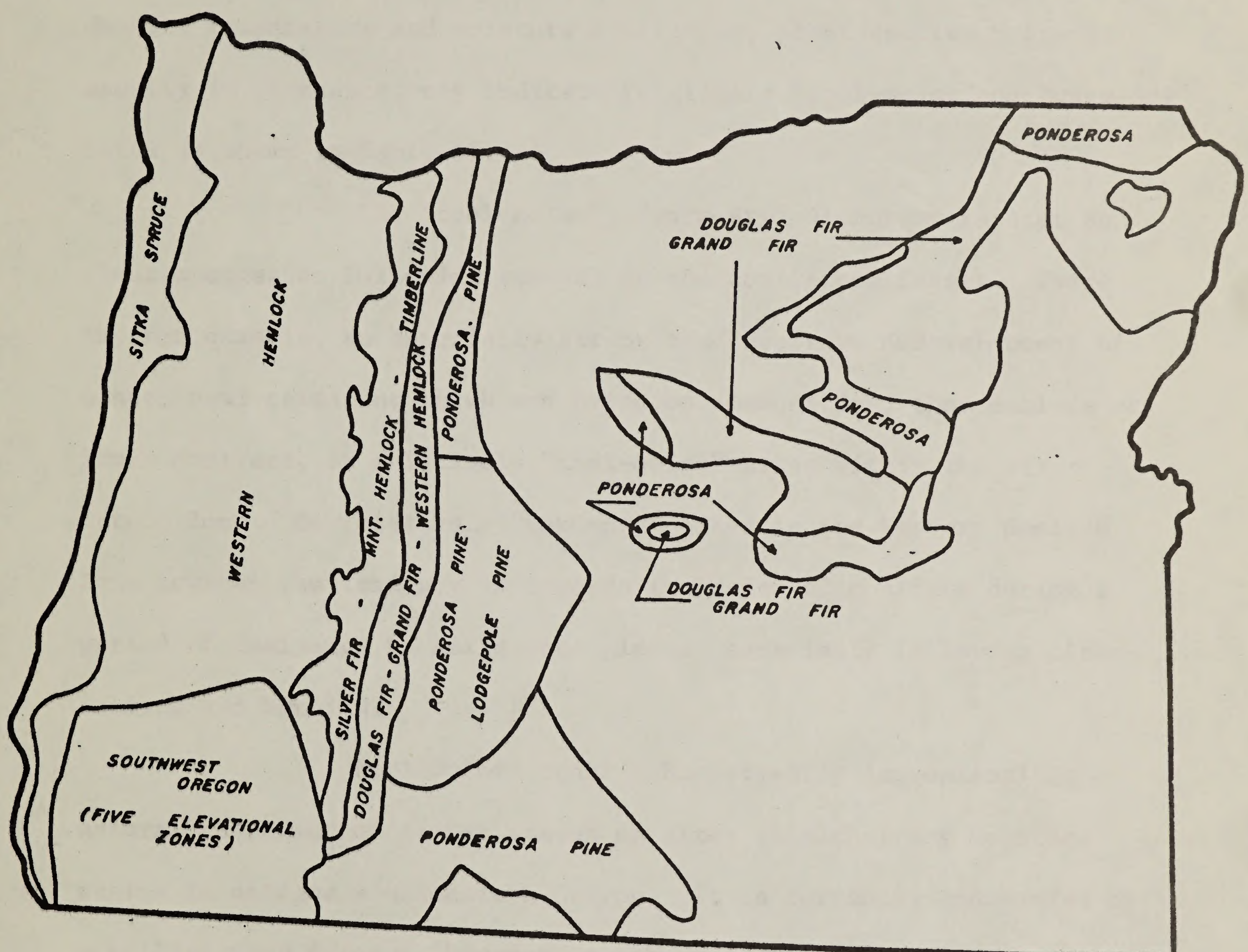
NORTHWEST COASTAL SUB-BIOME

MAJOR SPECIES OCCURRENCE BY ZONES 1/

Species	Sitka Spruce 2/	Western Hemlock 2/	Pacific Silver Fir	Mountain Hemlock	Timber-line
Western White Pine (Pinus monticola)	4	3	2	3	4
Sugar Pine (Pinus lambertiana)	4	3	3	3	4
Whitebark Pine (Pinus albicaulis)	4	4	4	2	1
Lodgepole Pine (Pinus contorta)	1	4	2	3	3
Ponderosa Pine (Pinus ponderosa)	4	4	4	4	4
Western Larch (Larix occidentalis)	4	4	3	3	4
Engelmann Spruce (Picea engelmannii)	4	4	2	2	2
Sitka Spruce (Picea sitchensis)	2	3	4	4	4
Western Hemlock (Tsuga heterophylla)	1	1	2	3	4
Mountain Hemlock (Tsuga mertensiana)	4	4	2	2	2
Douglas-fir (Pseudotsuga menziesii)	1	1	2	3	4
Grand Fir (Abies grandis)	2	2	3	4	4
Pacific Silver Fir (Abies amabilis)	4	3	1	2	3
White Fir (Abies concolor)	4	4	4	4	4
Noble Fir (Abies procera)	4	3	2	3	4
Shasta Red Fir (Abies magnifica)	4	4	3	3	3
Subalpine Fir (Abies lasiocarpa)	4	4	2	2	2
Redwood (Sequoia sempervirens)	2	4	4	4	4
Insense-Cedar (Libocedrus decurrens)	3	2	3	4	4
Western Redcedar (Thuja plicata)	2	2	3	4	4

1/ 1 = abundant, 2 = common, 3 = uncommon, 4 = rare or absent
2/ Zones containing significant amounts of BLM acreage.

GENERAL LOCATION MAP
CONIFEROUS FOREST ZONES



Numerous vegetative associations have been described (by several authors) for the "Sitka Spruce" and "Western Hemlock Zones" of the Northwest Coastal Forest. (Franklin and Dyrness 1973). Since these plant communities reflect variations in on-site temperature and moisture conditions, plant species present, usually in abundance, may indicate relatively "cool-moist" or "warm-dry" sites as shown in Table II.

The "cool-moist", "warm-dry" dichotomy relates to plant succession following removal of the coniferous forest. There is, for example, an especially strong tendency towards development of dense, semi-permanent shrub and hardwood communities, that exclude or limit conifers, on relatively "cool-moist" sites within the Sitka Spruce Zone. On relatively "warm-dry" sites in the Western Hemlock Zone however the tendency is towards exclusion of conifers during a period of dominance by herbaceous plants, especially following clear-cutting and burning.

Port Orford cedar (Chamaecyparis lawsoniana) is a natural component of timber stands on sites of almost any moisture regime in extreme southwestern Oregon. It is currently endangered by a killing root disease, however, to the extent that it has nearly been eliminated from moist sites and could possibly be eliminated from most of its natural range.

f. Montane Forest

Forests of this sub-biome generally reproduce with difficulty or grow slowly, have relatively open canopies, and tend to

TABLE II

Species (X=Presence)	SITE Cool-Moist	Warm-Dry
TREES (C = Canopy only, R = Reproducing under canopy)		
Douglas-fir (Pseudotsuga mensiesii)	X(C)	X(R)
Incense-Cedar (Libocedrus decurrens)		X
Ponderosa Pine (Pinus ponderosa)		X
Sitka Spruce (Picca sitchensis)	X	
Western Hemlock (Tsuga heterophylla)	X	
Western Redcedar (Thuja plicata)	X	
BROADLEAF TREES OR SHRUBS		
Red Alder (Alnus rubra)	X	
Pacific Madrone (Arbutus menziesii)		X
Golden Chinkapin (Castanopsis chrysophylla)		X
Oregon White Oak (Quercus garryana)		X
Ocean spray (Holodiscus discolor)		X
Salal (Gaultheria shallon)		X
California hazel (Corylus cornuta calif.)		X
Rhododendron (Rhododendron macrophyllum)		X

have sparse understory, shrub and herbaceous layers (exceptions are commonplace). Plant succession following removal of the forest in this sub-biome usually follows the three stages outlined for the Northwest Coastal Forest; i.e., herbs, to shrubs, to conifers. Also as in the Northwest Coastal Forest, one or both of the first two stages may not occur on any given area, or may persist for an exceedingly long period of time. To facilitate the vegetative description the Montane Forest is divided into two regions, (1) Southwestern Oregon and (2) Eastern Oregon.

(1) Southwestern Oregon

This region may be viewed as having five major (elevational) zones (Franklin & Dyrness, 1969, pp. 77-103). From low to high elevation these are, (1) the "Mixed Conifer & Mixed Evergreen Zone", (2) the "White Fire Zone", (3) the "Red Fir Zone", (4) the "Mountain Hemlock Zone", and (5) "Timberline" (See Figure 18). As with the Northwest Coastal Forest, these zones reflect climatic conditions inherent with elevational differences. The lowest zone, the "Mixed Conifer & Mixed Evergreen" is warm and dry while higher zones, such as the "Red Fir" and "Mountain Hemlock" zones are cool and moist.

Major tree species found within this region and their occurrence within the major zones are estimated on Table III.

Within the "Mixed Conifer and Mixed Evergreen" and "White Fir" zones, relatively "cool-moist" and "warm-dry" sites may be indicated by the presence usually in abundance, of the species

TABLE III

MONTANE SUB-BIOME

MAJOR SPECIES OCCURRENCE BY ZONE[1/]

S.W. Oregon Region

Species	Mixed C. or E. [2/]	White Fir [2/]	Red Fir	Mount. Hem.	Timber-line
	ZONES				
Western White Pine (Pinus monticola)	3	3	3	3	4
Sugar Pine (Pinus lambertiana)	2	3	3	3	4
Whitebark Pine (Pinus albicaulis)	4	4	3	2	1
Lodgepole Pine (Pinus contorta)	3	3	3	3	2
Ponderosa Pine (Pinus ponderosa)	2	3	4	4	4
Jeffrey Pine (Pinus jeffreyi)	3	3	4	4	4
Engelmann Spruce (Picea engelmannii)	4	4	3	3	3
Western Hemlock (Tsuga heterophylla)	3	4	4	4	4
Mountain Hemlock (Tsuga Mertensiana)	4	4	3	1	2
Douglas-fir (Pseudotsuga menziesii)	2	2	4	4	4
Grand fir (Abies grandis)	3	4	4	4	4
Pacific Silver Fir (Abies amabilis)	4	3	2	4	4
White Fir (Abies concolor)	2	1	3	4	4
Noble Fir (Abies procera)	4	4	3	4	4
Shasta Red Fir (Abies magnifica var. shastensis)	4	3	1	2	3
Subapline Fir (Abies lasiocarpa)	4	4	3	2	2
Incense-Cedar (Libocedrus decurrens)	2	2	3	4	4
Western Redcedar (Thuja plicata)	3	3	4	4	4

1/ 1 = abundant, 2 = common, 3 = uncommon, 4 = rare or absent
2/ Zones containing significant amounts of BLM acreage.

shown on Table IV (Franklin and Dyrness, Ibid.) (Waring, 1969, pp. 1-17) (Minore, 1972 p. 25):

Plant succession is normally slow following removal of the forest on relatively "warm-dry" sites in the "Mixed Conifer and Mixed Evergreen" and "White Fir" Zones; establishment of coniferous seedlings may require as much as 25 years or more. Plant succession on relatively "cool-moist" sites, however, is normally more rapid provided other interfering conditions, such as animal damage, is not limiting.

A notable successional characteristic within these zones is a strong tendency towards development of extensive, dense brushfields of dry-site species and subsequent delay in establishment of coniferous seedlings, especially where fire has occurred (Franklin & Dyrness 1969, pp. 77-103). Species common to this successional stage are often those typical of the Broad Sclerophyll.

(2) Eastern Oregon

This region may be viewed in terms of (climax) zones. (Franklin and Dyrness 1969, pp. 110-140). The seven zones present include (1) the (usually) lowermost "Ponderosa Pine Zone"; mid-elevational zones of (2) "Douglas-fir", (3) "Grand (or White) Fir", (4) "Lodgepole Pine" and (5) "Western Hemlock"; (6) the higher "Subalpine Fire Zone", and (7) "Timberline" (See Figure 18). Throughout this region an important distinction is that zones do not always occur on a single mountain, nor do they always occur in sequential belts. Depending upon locale, the upper limit of the "Ponderosa Pine

TABLE IV

Species (X = Presence)

TREES	SITE Cool-Moist	Warm-Dry
Shasta Red Fir (Abies magnifica)	X	
Incense-Cedar (Libocedrus decurrens)		X
Western Hemlock (Tsuga heterophylla)	X	
Western Redcedar (Thuja plicata)	X	
Tanoak (Lithocarpus densiflorus)		X
Pacific Madrone (Arbutus menziesii)		X
Golden Chinkapin (Castanopsis chrysophylla)		X
Canyon Live Oak (Quercus chrysolepis)		X
Oregon White Oak (Quercus garryana)		X
Calif. Black Oak (Quercus kelloggii)		X
SHRUBS & HERBS		
Poison Oak (Rhus diversiloba)		X
Rose (Rosa)		X
Trailing Blackberry (Rubus ursinus)		X
Vine Maple (Acer circinatum)	X	
Pacific Dogwood (Cornus nuttallii)	X	
Pale Serviceberry (Amelanchior pallida)		X

Zone" for example, may grade into any of the four mid-elevational zones. Also, the "Ponderosa Pine Zone" may be absent; the Juniper or Cold Desert sub-biomes then grade into the Douglas-fir or other mid-elevational zone. Generally speaking, the "Ponderosa Pine Zone" is warm and dry and the "Subalpine Fire Zone" cool and moist; other zones are modal in this regard.

Major tree species found within the region and their occurrence within the major zones are estimated on Table V.

Relatively "cool-moist" and "warm-dry" sites can also be identified throughout the "Ponderosa Pine Zone" (Franklin and Dyrness 1969, pp. 110-122). Species indicative of these sites are shown on Table VI.

Relatively "cool-moist" sites in the "Ponderosa Pine Zone" may be ecotonal due to their close resemblence to the more mesic (moist) Douglas-fir or other mid-elevational zones. Relatively "warm-dry" sites exhibit a tendency to develop sclerophyllic brushfields following fire or other removal of the forest canopy (Franklin and Dyrness, Ibid).

In mid-elevational zones, especially the "Douglas-fir Zone", a past history of frequent, light fires has maintained Ponderosa pine as the dominant species over extensive areas (Franklin and Dyrness, Ibid). Absence of fire and selective logging may therefore contribute to replacement of Ponderosa pine with other species on certain sites while clearcutting and burning may tend to produce sclerophyllus brushfields in others (Franklin and Dyrness 1969, pp. 110-112 and 127-136).

TABLE V

MONTANE SUB-BIOME

MAJOR SPECIES OCCURRENCE BY ZONE1/

E. Oregon Region

Species	2/ Pond. Pine	3/ Lodge. Pine	3/ Doug. Fir	Grand White Fir	3/ West. Hem.	Sub. Fir.	Timber-line
Western White Pine (Pinus monticola)	4	4	4	3	2	3	4
Sugar Pine (Pinus lambertiana)	4	4	4	3	4	4	4
Whitebark Pine (Pinus albicaulis)	4	4	4	4	4	2	1
Lodgepole Pine (Pinus contorta)	2	1	2	2	2	1	3
Ponderosa Pine (Pinus ponderosa)	1	3	2	2	4	3	4
Western Larch (Larix occidentalis)	4	4	2	2	3	3	3
Engelmann Spruce (Picea engelmanii)	4	4	4	3	3	1	2
Western Hemlock (Tsuga heterophylla)	4	4	3	4	1	4	4
Mountain Hemlock (Tsuga mertensiana)	4	4	4	3	4	3	2
Douglas-fir (Pseudotsuga menziesii)	3	4	1	2	2	4	4
Grand Fir (Abies grandis)	3	4	3	1	2	3	4
White Fir (Abies concolor)	3	4	3	1	3	4	4
Shaste Red Fir (Abies magnifica var. shastensis)	4	4	4	3	4	4	4
Subalpine Fir (Abies lasiocarpa)	4	4	4	4	4	1	2
Incense Cedar (Libocedrus decurrens)	4	4	3	3	4	4	4
Western Redcedar (Thuja plicata)	4	4	3	4	2	4	4

1/ 1 = abundant, 2 = common, 3 = uncommon, 4 = rare or absent
2/ "strict" sense as described by Franklin and Dyrness 1969, p. 112, i.e., does not include seral ponderosa pine in Douglas fir or other zones.
3/ Zones containing significant amounts of BLM acreage.

TABLE VI

Species (X = Presence)	SITE Cool-Moist	SITE Warm-Dry
TREES		
Douglas-fir (Pseudotsuga menziesii)	X	
Grand Fir (Abies grandis)	X	
Western Juniper (Juniperus occidentalis)		X
Oaks (Quercus)		X
SHRUBS & HERBS		
Common snowberry (Symphoricarpus albus)	X	
Mallow ninebark (Physocarpus malvaceus)	X	
Idaho fescue (Festuca idahoensis)		X
Bluebunch wheatgrass (Agropyron spicatum)		X
Needle & Thread (Stipa comata)		X
Bitterbrush (Purshia tridentata)		X
Blue Wildrye (Elymus glaucus)		X
Elk sedge (Carex geyeri)	X	
Mountain mahogany (Cercocarpus)	X	
Wheeler bluegrass (Poa nervosa)	X	
Strawberry (Fragaria)	X	
Fireweed (Epilobium angustifolium)	X	
Hawkweed (Hieracium)		X

2. Aquatic Vegetation

Vegetation is a vital component of aquatic ecosystems because plants are the beginning of the food chain--only they can fix biochemical energy and synthesize basic organic substances (Environmental Protection Agency, 1-10). Aquatic plants therefore provide food and cover for insects, other invertebrates, fish, waterfowl, fur bearers, big game, and non-game birds and animals. Growth of aquatic vegetation along stream banks and lakeshores prevents soil erosion and contributes to the natural beauty of the ecosystem.

Some aquatic plants grow in nearly all waters of the state depending on suitable temperature, water depth and movement, available nutrients, salinity, light for photosynthesis, and sufficient time for growth and reproduction. The aquatic environment is often classified as either running (lotic) or standing (lentic) water habitat.

The running water habitat includes the smallest mountain streams at high altitudes to major rivers at low elevations. Water originating in all watersheds, except the closed desert drainages in Lake and Harney Counties, eventually enters the Pacific Ocean. Streams at higher elevations generally contain less vegetation than those at lower elevations due to steeper gradients, cooler water, and a lower concentration of nutrients.

Lakes, reservoirs, ponds, marshes and bogs make up the standing water habitat of Oregon. A greater variety and more abundant growths of vegetation usually occur in standing than in running water

environments. Natural lakes can be classified into three groups according to their morphometry and productivity (EPA, 1-18).

- Young. (Oligotrophic). Geologically young, less productive lakes; deep with narrow shoals (littoral zone) or none; clear water of blue to green color; low in nitrogen and phosphorous; low in phytoplankton; and few macrophytes or higher, vascular plants in the littoral zone.
- Maturing. (Eutrophic). Geologically more mature and productive lakes; usually shallow with broad shoals; color green to yellow and brownish green with low transparency; rich in nitrogen and phosphorous; rich in phytoplankton with dense blooms; and littoral plants abundant.
- Old. (Dystrophic). Lakes in bog surroundings or in geologically old land areas; acidic waters yellow to brown with low transparency; low in nitrogen and phosphorous; phytoplankton low with rare blooms; few littoral plants but rich in humic materials.

Most young lakes are found at higher elevations in the coniferous Forest Biome, whereas maturing lakes occur in all biomes at all elevations. Mature lakes, ponds and marshes (both marine and freshwater, including estuaries) are areas of enormous biological productivity because of the rich waters and abundant communities of aquatic vegetation.

Aquatic plants are usually grouped into three general categories - floating, submersed and emersed. Representative plant species widespread in Oregon and probably common to all sub-biomes are listed by genera as follows: (Peck, 1961 and Steward, et al., 1960).

- Floating. Green and blue-green algae; duckweed (Lemna and Spirodela); water shield (Brasenia); pond lily (Nuphar); and floating pondweed (Potamogeton).
- Submersed. Stonewort (Chara); bladderwort (Utricularia); some pondweed (Potamogeton); Hornwort (Ceratophyllum); water milfoil (Myriophyllum); water buttercup (Ranunculus); mare's trail (Hippuris); and elodea (Elodea).
- Emersed. Cat-tail (Typha); bulrush (Scirpus); yellow cress (Rorippa); buttercup (Ranunculus); bur-reed (Sparganium); water persicaria (Polygonum); water plantain (Alisma); arrowhead (Saggittaria); sedge (Carex); spikerush (Eleocharis); horsetail (Eouisetum) cyperus (Cyperus); rush (Juncus); mannagrass (Glyceria); common reed (Phragmites); slough grass (Beckmannia); reed canarygrass (Phalaris); willow (Salix); alder (Alnus) and cottonwood (Populus).

Some aquatic species are adaptable to wide variations in environment and can often survive adverse growing conditions. Examples of species with widespread distribution in Oregon were listed above. Other species are restricted in distribution to more specific conditions. For example, two conspicuous very important marine species

are eel-grass (Zostera marina) and Bull kelp (Nerecystis luetkeana). Eel grass grows primarily in the intertidal zone of estuaries and the open coast, whereas bull kelp (a brown algae) usually grows in less than 60 feet of water in areas protected from the prevailing winds and on the inshore side of reefs (Waldon, 1955). The range of many other species is dependent upon altitude and climatic conditions. The green sedge (Carex viridula) grows in sphagnum bogs along the coast, while the cold-living sedge (Carex ablata) lives in alpine bogs. Seashore saltgrass (Distichis spicata) grows mainly in salt marshes on the coast, whereas desert saltgrass (Distichis stricta) occurs on wet alkaline areas east of the Cascades.

Aquatic plants tend to grow in communities according to water depth, which is probably the major habitat requirement on most species. In aquatic ecosystems some plants occur in open water, others occupy the littoral zone, and different species grow along the shores of lakes and banks of rivers.

Algae, for example, occur in deep, open water, duckweed is also found floating in deep water but occurs at all water depths; rooted vegetation is restricted to the littoral zone where light penetrates to allow dense beds of submersed plants (water milfoil, elodea, pondweeds, hornwort) to occur. As inshore water depth decreases, submersed species intermingle with other rooted floating plants such as pondweed, pond lily, and watershield. Vegetation dominating the shallower water and shoreline includes cat-tail, bulrush, mannagrass,

buttercup, water cress, arrowhead bur-reed, sedge, rush, slough grass, reed canary-grass, willow and alder.

Plant communities in standing water environments are constantly changing due to natural processes. Shoal areas, for example, are developed by sedimentation from shore erosion and tributary streams. Rooted vegetation grows on the shoals and contributes to filling of lakes by retaining debris and sediment. Tributary streams continue to add more nutrients. Dense growth of emergent plants extend outward from shore. Dead plant material accumulates and further fills the lake. Succession of grasses and sedges then converts the lake into marshes or bogs, and finally dry land. Plant succession is therefore an important factor in the gradual conversion of water bodies to land, which is a long-term process requiring hundreds of years to complete under natural conditions.

Many lakes in southeastern Oregon have gradually dried up or now fill only a small part of their former basins. Climatic changes and uses of water have been the dominant factors in the loss of many lakes, but in some cases abundant growth of aquatic plants hastened the conversion of some lakes to alkaline land.

H. Animals

1. Terrestrial Wildlife

A wide variety of terrestrial animals are found in Oregon since under pristine conditions, the basic requirements of food, water, cover and space are usually well met for most species. Some animal species are represented in all six sub-biomes. Others, more specific in their requirements, are found in only one or two. The following terrestrial wildlife families are generally found throughout Oregon.

Mammals

Deer - (Cervidae)

Bears - (Ursidae)

Coyotes & Foxes - (Canidae)

Squirrels - (Sciuridae)

Mice, Rats & Moles - (Cricetidae)

Beavers - (Castoridae)

Wildcats & Cougar - (Felidae)

Rabbits & Hares - (Leporidae)

Weasels - (Mustilidae)

Bats - (Vespertilionidae)

Birds

Hawks & Eagles - (Accipitridae and Falconidae)

Vulture - (Cathartidae)

Owls - (Tytonidae and Strgidae)

Jays, Magpies & Crows - (Corvidae)

Grouse - (Tetraonidae)

Ducks, Geese - (Anatidae)

Woodpeckers - (Picidae)

Wrens - (Troglodytidae)

Finches & Sparrows - (Fringillidae)

Reptiles & Amphibians

True toads - (Bufonidae)

True frogs - (Ranidae)

Garter & Gopher snakes - (Colubridae)

Insects & Arachnids

Grasshoppers - (Acrididae)

Wasps & hornets - (Vespidae)

Ants - (Formicidae)

(Pacific N.W. River Basin Comm. pgs. 29-43)(Bailey, 1936)

Rare & Endangered Wildlife

The following species found in Oregon are listed as rare or endangered, nationally, by the Bureau of Sport Fisheries and Wildlife. In some cases, the habitat is quite restricted.

Columbian white-tailed deer - (Odocoileus virginianus leucurus)

California bighorn sheep - (Ovis canadensis californiana)

American peregrine falcon - (Falco peregrinus anatum)

Arctic peregrine falcon - (Falco peregrinus tundrius)

Wallowa grey-crowned rosy finch - (Leucosticite tephrocotis)

(Bureau of Sport Fisheries & Wildlife - Conservation of Endangered Species, 1970)

In addition to the species listed as rare or endangered nationally, the State of Oregon lists the following wildlife as rare or endangered in Oregon. In some cases, the habitat is confined to a small area.

Mammals

Richardson ground squirrel - (Spermophilis richardsoni)

Kit fox - (Vulpes macrotis)

Wolverine - (Gulo luscus)

Lynx - (Lynx canadensis)

Sea otter - (Enhydra lutris)

Northern elephant seal (Mirounga anqustirostris)

Malheur shrew - (Sorex preblei)

Ashland shrew - (Sorex trigonirostris)

Merriam shrew - (Sorex merriami)

Brazilian free-tailed bat - (Tadarida brasiliensis)

White-footed vole - (Aborimus albipes)

Ringtailed cat - (Bassariscus astutus)

Fisher - (Martes pennanti)

Unfortunately the Wolf (Canis lupus), Bison (Bison bison) and Grizzly Bear (Ursusarctos) are no longer found in Oregon.

Birds

Ferruginous hawk - (Buteo regalis)

Northern bald eagle - (Haliaeetus leucocephalus alaskanus)

Franklins spruce grouse - (Canachites canadensis franklinii)

Columbian sharp-tailed grouse - (Pedioecetes phasianellus columbianus)

Flammulated owl - (Otus flammeolus)

Northern spotted owl - (Strex occidentalis caurina)

Western snowy plover - (Charadrius alexandrimus nivosus)

Great gray owl - (Strix nebulosa nebulosa)

Alaska northern three-toed woodpecker - (Picoides tridacylus fasciatus)

(Marshall, 1969) (O.G.C. 1973)

Amphibians & Reptiles

Cope's giant salamander - (Dicamptodon copei)

Larch mountain salamander - (Plethodon larselli)

Siskiyou mountain salamander - (Plethodon stormi)

Oregon slender salamander - (Batrachoseps wrighti)

Black salamander - (Aneides flavipunctatus)

Tailed frog - (Ascaphus truei)

Western spotted frog - (Rana pretiosa pretiosa)

Collard lizard - (Crotaphytus collaris)

Leopard lizard - (Crotaphytus wislizeni)

Sharp-tailed snake - (Contia tenuis)

(Storm, 1966) (O.G.C. 1973)

Beside consumptive use, thousands of outdoor recreationists enjoy wildlife photography, viewing, and other forms of non-consumptive recreation. Thousands of migrating waterfowl and shore birds utilize

Oregon waters from the coast to the Snake River for feeding and resting on their flights to and from northern breeding areas. These bird concentrations provide an excellent opportunity for bird-watching and photography.

While consumptive and non-consumptive wildlife use demand increases, wildlife populations appear to be decreasing in many parts of the State. Loss of some northern breeding habitat for waterfowl, a loss of nesting and wintering cover for some species of upland game birds, and the impact of severe winters and marginal winter range conditions on big game species have reduced population of both game birds and animals. Clean farming practices, instances of overgrazing and overcutting of timber, changing land use patterns, and increased recreational use of former "wild" lands have also reduced non-game bird and animal numbers through loss of habitat.

a. <u>Forest Sub-biomes - General</u>

<u>Habitat Requirements</u> - Wildlife typical of the forests are generally adapted to a closed canopy of coniferous timber interspersed with small openings. Some species, including the herbivors, such as deer and elk, respond to an edge effect created by forest meadows, logging, or fires that allow development of a nutritious understorm of vegetation. Other species, including the raptors and larger predators, may respond adversely to loss of the timber overstory, especially if it is accompanied by human activity. Accipter hawks and the horned and northern spotted owls depend on tree-dwelling mammals for their prey, such as the red-backed mouse, red and flying squirrels, and the small birds that are

found in forested areas. Bald eagles and ospreys need dead and dying trees adjacent to lakes, streams and the ocean for nest sites since their prey is principally fish.

Many fur-bearers and birds are adapted to a semi-aquatic habitat, and the presence of streams, lakes and ponds add greatly to the variety of wildlife. Permanent supplies of clean water should be available to wildlife at all times. In a so-called "virgin forest" this is usually not a limiting factor. Most forest wildlife can adapt to certain habitat changes, but extensive human activities is greatly detrimental to many species, especially when accompanied by vehicles.

b. Northwest Coastal Forest

The Northwest Coastal Forest grows in an area where water is usually not a severe limiting factor. Humidity is high and the temperature range is narrow. There is usually a deep layer of duff and organic soil rich in micro-organisms. The huge trees produce dense shade resulting in a poorly developed understory of nutritious browse species. Common animals include:

Mammals

Roosevelt elk - (Cerbus canadensis roosevelti)

Blacktailed deer - (Odocoileus hemionus columbianus)

Black bear - (Euarctos americanus)

Oregon bobcat - (Lynx rufus fasciatus)

Oregon cougar - (Felis concolor oregonensis)

Mtn. Beaver (Sewellel) - (Aplodontia rufa)

Pocket gopher - (Thomomys hesperus)

Oregon brush rabbit - (Sylvilagus bachmani uvericolor)

Douglas chickaree - (Sciurus douglasii)

Red tree mouse - (Phenacomys longicaudus)

Birds

Northwest coast bat - (Myotis californicus caurinus)

Pacific horned owl - (Bubo virginianus pacificus)

Northern spotted owl - (Strix occidentalis caurina)

Cooper's hawk - (Accipter cooperi)

Bald eagle - (Haliaeetus leucocephalus)

Sooty grouse - (Dendragapus fuliginosus)

Winter wren - (Nannus hiemalis pacificus)

Band-tailed pigeon - (Columbia fasciata fasciata)

Pileated woodpecker - (Ceolophloeus pileatus picinus)

Townsend's Warbler - (Dendroica towsendi)

(Bailey, 1936, Peterson 1941)

Amphibians and Reptiles

Pacific giant salamander - (Dicumptodon ensatus)

Puget Sound garter snake - (Thamnophis sirtalis)

Pacific rubber boa - (Charina bottae bottae)

Other wildlife are found in more specific zonal types: The hemlock looper (Ellopia fascellaria lugubrosa) and the Sitka spruce beetle (Dendroctonus obesus) are serious defoliatore.

In the Coastal Douglas Fir zone, the Trowbridge's shrew (Sorex trowbridgii t.), an insectivore, feeds on Douglas fir seed. The Larch Mountain salamander, considered endangered by the State of Oregon, is found in the north Cascades.

The fisher (Martes pennanti pacifica) and the rare flammulated owl, (Otus flammeolus) are found in the forested areas below timberline.

The wolverine, also considered endangered by the State, and further north, the white crowned sparrow (Zenotrichia leucophrys) are found in alpine habitat. The endangered Oregon white-tailed deer is found in the Roseburg area and along the bottomlands of the lower Columbia River. (Willamette Basin Task Force, pp. 151-198) (Bailey, 1936, pp. 31-41)

Habitat Requirements - This sub-biome has the ability to produce desirable habitat following fires, logging, and other disturbances to the overstory more rapidly than Montane forests due to better soils, moisture conditions and lower elevations. Water is not usually a limiting factor.

Deer and elk generally follow any natural or man-made opening in the dense overstory, such as caused by fires or logging, to take advantage of resulting nutritious ground vegetation. Closed canopy forests that provide winter cover and escape shelter are a crucial part of game animal habitat.

The cougar, black bear and northern lynx inhabiting this sub-biome are wilderness species that need the seclusion and escape

cover afforded by dense forests.

Many of the small mammals and birds, and amphibians found in coastal forests depend on the variety of insect life that abounds in the damp mild environment, as well as the great mass of seeds produced by evergreen trees.

Mink, marten, otter, beaver, and muskrat favor this habitat due to the proximity of lakes and streams that afford food, bank dens, and travel routes. While waterfowl are not normally considered as representative birds of timbered habitat, many ducks use the lakes, rivers, and estuaries adjacent to the moisture-holding forest lands. Some ducks, including the golden-eye, bufflehead, and wood duck, nest in tree cavities adjacent to water.

In addition to the terrestrial wildlife listed for the Northwest Coastal Forest many forms of aquatic and semi-aquatic wildlife (birds and mammals) inhabit the estuaries and immediate coastal zone. These include the following:

Mammals

Sea otter - (Enhydra lutris)

Pacific harbor seal - (Phoca richardii richardii)

California harbor seal - (Phoca richardii geronimensis)

California sea lion - (Zalophus californianus)

Other mammals could include the endangered sea elephant, various other sea lions, and the gray whale. (Game Commission - Checklist of Oregon Mammals)

Birds

Common loon - (Gavia immer)

Brown pelican - (Pelicanus occidentalis californicus)

Brandt's Cormorant - (Phalacrocorax penicillatus)

Western grebe - (Aechmophorus occidentalis)

Red-breasted merganser - (Mergus serrator)

Least sandpiper - (Pisobia minutilla)

Sanderling - (Crocethia alba)

Northwest coast heron - (Ardea herodias fannini)

Western gull - (Larus occidentalis)

Common Murre - (Uria aalge californica)

Black brant - (Branta nigricans)

Surf scoter - (Melanitta perspicillata)

Many other species of shorebirds and waterfowl use this important coastal habitat as residents or migrants. The northern bald eagle and osprey are also often found along rivers, bays and estuaries. (Bailey 1936, Peterson, 1941, Bertrand and Scott, 1971). These species are dependent on clean brackish or salt water and the adjacent beaches or mudflats for their immediate habitat or for the plants or animals that constitute their food supplies.

c. Montane Forest

A greater variety of habitat exists in this sub-biome than in the coastal forest, due to the variety of vegetative types. This allows a high degree of use by adaptable wildlife. Representative species includes:

Mammals

Rocky mountain elk - (Cervus canadensis nelsoni)

Mule deer - (Odocoileus hemionus hemionus)

Golden-mantled ground squirrel - (Callospermophilus chrysoderius chrysoderius)

Canada lynx - (Lynx canadensis)

Rocky mountain cougar - (Felis concolor hippolestes)

Black bear - (Euarctos americanus)

Rocky mountain marten - (Martes caurina origenes)

Pika - (Ochotona princeps brunnescens)

Oregon snowshoe hare - (Lepus americanus klamathensis)

Birds

Big brown bat - (Eptesicus fuscus fuscus)

Golden eagle - (Aquila chrysaetos canadensis)

Barrow's golden eye - (Glancionetta islandica)

Rocky mountain pigmy owl - (Glaucidium gnoma)

Great gray owl - (Strix nebulosa nebulosa)

Oregon jay - (Perisoreus obscurus obscurus)

Three-toed woodpecker - (Picoides tridactylus)

Red-tailed hawk - (Buteo borealis)

Clark's nutcracker - (Nucifraga columbiana)

Mountain quail - (Oreontyx picta palmeri)

Amphibians and Reptiles

Pacific tree frog - (Hyla wrighorum)

California mountain kingsnake - (Lampropelis zonata)

(Bailey, 1936, pp. 31-41) (Pacific N.W. River Basin Comm., 1971, pp. 250-275)

Insects

Oregon rain beetle - (Plecoma oregonensis)

As with the coastal forest sub-biome, many other wildlife species are found by regions of the Montane Forest such as the rare black salamander.

On the east slopes of the Cascades, the Roosevelt elk and Rocky mountain elk have intermingled until it is difficult to differentiate between the two subspecies (Oregon Game Commission bulletin, July 1972). Parts of this zone may have heavy blacktailed deer concentrations as well as mule deer populations. The Douglas ground squirrel (Otospermophilis grammurus douglasii) is common in the mixed forests of this area as is the Northern Pacific rattlesnake (Crotalis virdis). Destructive beetles, such as the bark beetle (Ips emarginatus) infest Ponderosa pine.

The Eastern Oregon portion of the Montane Forest may be represented by the Cascade hoary marmot (Marmota caligata canadensis), Rock wren (Salpinctes obsoletus O.) and the boreal toad (Bufo boreas). The Idaho while-tailed deer (Odocoileus virginianus ochrourus) is found in the Blue Mountains near the Washington border. The Rocky Mountain bighorn (Ovis canadensis canadensis) and the Mountain goat (Oreamnas americanus) have been reintroduced into this sub-biome. It is not believed, however, that the mountain goat was originally found in Oregon (Bailey, 1936).

Wildlife species characteristic of the Blue and Wallowa Mountains Montane sub-biome include the Idaho flying squirrel (Glaucomys

sabrinus bullatus) Rocky mountain meadow mouse (Microtus mordax mordax), Canada lynx (Lynx rufus yinta), and the silver haired bat (Lasionycteris noctivagans). Birds include the Richardon's grouse (Dendragopus obscurus richardsonii), Franklin's grouse (Canachites franklini) and the Rocky mountain jay (Perisoreus canadensis capitalis).

The endangered Wallowa gray-crowned rosy finch is also found here.

Habitat Requirements - Water can be a limiting factor in Oregon sites of portions of this sub-biome. The diversity of habitat and climatic conditions produces a diversity of wildlife. Woodpeckers make extensive use of the oaks and other hardwoods found in parts of this sub-biome for food, food storage and nesting. Many other birds and small animals also use cavities in dead and dying trees as nest and den sites. The many herbivores inhabiting this sub-biome utilize most of the upper areas as summer range. Deep snows and cold preclude year-round residency for some species such as deer and elk. These ruminants must have suitable winter range within reasonable migration distance for survival. High mountain meadows, and vegetation above timberline is necessary for mountain sheep and goats for year-round habitat.

As noted for other timbered areas, the larger predators - wolverine, bear, and cougar - must have the privacy of wilderness to survive. (Much of this section on the Coniferous Forest biome was extracted, with modification, from the BLM draft on Timber Management Environmental Impact Statement, Section I, 1973.)

d. <u>Broad Sclerophyll</u>

A portion of the <u>Montane</u> forest merges with hardwood trees and brush in southwestern Oregon. The <u>Broad Sclerophyll</u> sub-biome adjacent to the Siskiyou, Klamath, and Cascade mountains contains many important wildlife species more closely related to California forms that to the Rocky Mountain species. Wildlife species include the

Dusky footed woodrat (Neotoma cinerea fusca)

Oregon gray fox (Urocyon cinereoargenteus townsendi)

Ringtail or Bassarisk

Pacific pale bat (Antrozous pallidus pacificus)

(Bailey, 1936, pp. 31-34)

<u>Birds</u>

Valley quail (Lophortyx californica vallicola)

Long tailed jay (Aphelocoma californica immanis)

Sacramento towhee (Pipilo maculatus falcinellus)

Red-shafted flicker (Colaptes cafer collaris)

Acorn woodpecker (Balanosphyra formiciuora)

(Gabrielson and Jerrett, 1940, pp. XXI - XXX)

<u>Reptiles and Amphibians</u>

Sharp-tailed snake

Siskiyou mountain salamander

Leopard salamander (Crotaphytus wislizeni)

(O.G.C. Checklist, 1972)

The Broad Sclerophyll is an extension of the transition zone of central Oregon, and some of the wildlife found along the fringes of the Rogue River valley are similar to central Oregon brushland species. For example, the magpie, sparrow hawk, Douglas ground squirrel, and black tailed jack rabbit are present. The Siskiyou mountain salamander and sharp-tailed snake are classified as endangered by the State.

Habitat Requirements - Wildlife are dependent on the great variety of transition zone hardwood trees and shrubs. Acorns provide food for tree and ground squirrels, certain woodpeckers, and woodducks and are readily used by blacktailed deer in the fall and winter. Ceanothus, manzanita, scrub oak, and mountain mahogany are preferred browse species for wintering deer. The Pokegama - Jenny Creek area on the California border provides winter range for the largest migrating blacktailed deer herd in Oregon.

This sub-biome can become very hot and a shortage of water can be a major limiting factor. Many small streams and ponds go dry during the summer. Some brushfields, especially those following wildfires, become too dense and stagnant to provide good wildlife habitat. Controlled burning or cutting to provide basal regeneration, and escapement of understory grasses and forbs would be beneficial practices.

Continuing road development, power line rights-of-way, brush cutting for pasture development and sub-urbanization of southwestern Oregon is rapidly eliminating much of the former brushlands around the Rogue, Illinois, and Umpqua Valleys. With the loss of the brushland, many

of the indigenous wildlife species lose their necessary habitat.

e. Cold Desert and Juniper Sub-biomes

These areas are extremely important to wildlife, since they constitute crucial winter range habitat for most mule deer herds, and form the year-round habitat for the many important desert-dwelling wildlife species found east of the Cascade foothills.

Water can be the most crucial of the habitat requirements, followed by winter food and cover availability. Wildlife in these sub-biomes is typified by fleetness of both birds and animals, and a jumping locomotion among many of the mammals. Many of the vertebrates and insects and arachnids are borrowing types, and all species are well adapted to a scarcity of free water and food. (BLM Preliminary Draft, Upland Oil and Gas Leasing Environmental Impact Statement.) Animals typical to these biomes include:

Mammals

Oregon grasshopper mouse - (Onachomys leucogaster fuscogriseus)

Pronghorn antelope - (Antelocapra americana)

Kit fox - (Vulpes fulva)

Badger - (Taxidae taxus)

Desert wood rat - (Neotoma desertorum)

Black-tailed jack rabbit - (Lipus californicus californicus)

Other mammals commonly found include the coyote, bobcat, skunks, ground squirrels, and mule deer that use the bushlands principally for wintering areas. Bats use lava caves and tubes extensively for day-

light resting and for hibernation.

The endangered California bighorn sheep (Ovis canadensis californiana) has been reintroduced into parts originally found throughout most of the Cold Desert area. Bison remains near Malheur Lake indicate the presence of these herbivores before the time of Lewis and Clark.

Birds

Turkey vulture - (Cathartes aura)

Sage grouse - (Centracercus urophasianus)

American magpie - (Pica pica hudsonia)

Prairie Falcon - (Falco mexicanus)

American Peregrine Falcon - (Falco peregrinus)

Sparrow Hawk - (Falco sparverius)

Mourning dove - (Zenaidura macroura)

Ferruginous hawk - (Buteo regalis)

The marsh hawk (Circus hudsonius) frequents lakes and marshlands within the Cold Desert. Marshes and reservoirs are heavily used by ducks, geese, and shorebirds. Of the above birds, the ferruginous and the peregrine hawks are considered endangered, nationally, and the prairie falcon is classed as rare.

Amphibians and Reptiles

Desert horned lizard - (Phrynosoma platyrhinos)

Wandering garter snake - (Thamnophis ordinoides vagrans)

(Bailey, 1936; Gabrielson and Jerrett, 1940)

Insects

Carolina grasshopper - (Dissosteria carolina)

Rocky Mountain woodtick - (Dermacentor renustus)

(Fernald and Shepard, 1955, pp. 85 and 363)

The sagebrush defoliator, a webworm (Aroga websteri) is found throughout the cold desert area, and has resulted in the loss of many thousands of acres of sagebrush.

In the most arid portions of the Cold Desert, specialized wildlife includes the plains rattlesnake (Crotalis confluentus), sagebrush chipmunk (Eutamias minimus pictus), Pinte ground squirrel (Citellus mollis mollis), and the desert scorpion (Hadrurus hirsutus). Birds are represented by the lead-colored bush tit (Saltriparus minimus plumbeus), the desert sparrow (Amphispiza bilineata deserticola), and the avocet (Recurvirostera americana) (Gabrielson and Jerrett, 1940). Many waterfowl nest and migrate through these sub-biomes as does the red-winged blackbird (Agelaius phoeniceus) and greater sandhill crane.

Habitat Requirements - Wildlife requirements vary greatly in the Cold Desert - Juniper sub-biomes. Central and eastern Oregon has a light human population in most areas; however, there is increasingly heavy seasonal recreation use especially with off-road vehicles. The space or wilderness requirement for many species of wildlife is becoming limited. Vehicular harassment can vary from cross country motorcycle races such as held on southern California desert lands, to invasion of deer and elk winter ranges by snow vehicles.

Desert vegetation is fragile. Light soils, low annual precipitation and short growing seasons result in the generally sparse vegetation crucial to wildlife for food and cover. Past overgrazing by livestock and wild herbivors has depleted forage on some winter ranges presently needed by big game species. Much of the present big game range is a result of overgrazing of grasses by cattle, sheep, and horses, permitting a shrub and juniper invasion. The presence of various brush species provide more food and shelter than available in a grass habitat. When juniper assumes a monotype with no understory, openings created by chaining or cutting create more edge effect and allows the repressed browse understory to develop. A mixture of grasses and brush provides the best habitat for most wildlife species in this sub-biome.

While most desert dwellers get along on vegetative succulence for water requirements, some must rely on springs, seeps, reservoirs, or natural lakes and ponds. Antelope, mule deer, most mammalion predators, and birds require free water on occasion. Most important, also, is the continuing need of reservoirs and ponds filled with clean water for the many species of waterfowl, shorebirds, and other bird life that inhabit the marshes of central and eastern Oregon. Major waterfowl concentrations are found on Harney and Malheur Lakes, Klamath, Summer and Abert Lakes, and the Warner Valley lakes. There water bodies serve both a habitat for resident species and provide food and resting areas for the many migrants that come through the state east of the Cascades. In addition to the necessary water supply, these birds must have a variety of aquatic vegetation - submergent, emergent, and floating for nesting, escape cover, and feeding. Drainage, pollution, overgrazing, reclamation, and other factors have seriously reduced many acres of former

habitat.

f. Palouse Prairie Grassland (Northeast)

The grasslands form habitat for many wildlife species; some are unique. Included are:

Mammals

Cottontail - (Sylvilagus nuttallii nuttallii)

Pigmy rabbit - (Brachylagus idahoensis)

Pocket gopher - (Thomomys townsendii nevadensis)

Many of the animals typical of Cold Desert mammals are found here including bobcats, coyotes, badgers, mule deer, and mice and ground squirrels. The pronghorn antelope once extended its range to the Columbia River, but, with the exception of small herds near Baker, is not found in the grasslands in the northeast part of the State. Some Rocky mountain elk winter along the grasslands of the Snake River, and deer herds winter in mixed grass and brushlands. All herbivors use grasses extensively during winter months and the spring green-up.

Birds

Sharp-tailed grouse - (Pedioecetes phasianellus columbianus)

Burrowing owl - (Speotyto cunicularia hypugaea)

Short-eared owl - (Asio flammeus flammeus)

Chukar partridge - (Alectoris graeca)

Hungarian partridge - (Perdix perdix perdix)

In addition to the above species, waterfowl and shore birds make extensive use of the reservoirs and ponds found in this sub-

biome. The Columbian sharp-tailed grouse was once found throughout the grasslands, but is now restricted to a small area near Baker. The chukar, and Hungarian partridges and the ringnecked pheasant (Phasianus colchicus torquatus) are introduced exotics that have readily adapted to grasslands and adjacent wheatlands. Of these three birds, the chukar is the most adaptable and widespread. (BLM Preliminary Draft, Upland Oil and Gas Leasing Environmental Impact Statement, 1972, page III-45)(Columbia N.W. River Basin Comm., XIV, pages 310-321)

Reptiles and Amphibians

Pacific rattlesnake - (Crotalus confluentus)

Western painted turtle - (Chrysemys marginata belli)

Western blue-bellied lizard - (Sceloporus occidentalis biseriatus)

(Bailey, 1936, page 35)

Insects

Grasshoppers - (Melanopis mexicanus)

(Fernald & Shepard, 1955, p. 85)

Habitat Requirements - Wildlife living in this sub-biome are dependent on grasses and forbs, and in some cases mixed shrubs, for their habitat requirements. Large wildlife species found here can be characterized as grazing animals along the smaller burrowing or running grass-eating mammals. Animals are usually gregarious and tend toward large concentrations.

As in requirements for the cold desert, waterfowl and shorebirds must have uncontaminated, stable, water levels for nesting,

resting and feeding. Water is sometimes in short supply, and any natural streams, springs, and seeps are heavily used by all resident wildlife. Cold Springs and McKay Reservoirs near Pendleton and Hermiston are very important waterfowl refuges. Ducks and geese using these reservoirs utilize adjoining grasslands and wheatlands to feed.

Rapid "development" of the Palouse Prairie Grasslands by agriculturists to commercial crops and pasturelands is changing the pristine sub-biome composition. Loss of original habitat has adversely affected species such as the Columbian sharptailed grouse and some waterfowl populations.

g. <u>Palouse Prairie Grassland (Southwest)</u>

This portion of the palouse prairie extends into the Rogue and Umpqua River valleys and is surrounded by the broad sclerophyll sub-biome. Most of the wildlife species in this portion of the grasslands range into the adjacent brushlands and are mainly identified with those species. In addition, the burrowing owl, marsh hawk, and California harvest mouse inhabit this area. Before the coming of the white man, the pronghorned antelope, and bison were found in the southwest palouse prairie habitat.

Some species found only in this sub-biome include the California meadow mouse, (Microtis californicus californicus) the northwest jumping mouse (Zapus trinotatus pacificus), Gabrielson's kangaroo rat (Dipodomys heermani gavrielsoni), and the Oregon brindled weasel (Mustila xanthogenys oregonensis). At one time, the ringtail cat was also present in the Rogue River valley (Bailey, 1936, p. 12).

Several species of waterfowl breed in and near this sub-biome. These include many common species such as the mallard and woodduck (Aix sponsa). (Gabrielson & Jewett, 1940.)

As with the northeastern Oregon Palouse Prairie Grassland, the grasslands of Rogue & Umpqua Valley areas has been even more drastically reduced than intensive agricultural practices and housing developments. Human harassment is a major limiting factor to resident wildlife species. The California Valley quail and the ringnecked pheasant were two species that had formerly adapted to the heavy human use of this sub-biome. At present, removal of winter and escape cover has substantially reduced their populations.

BLANK

2. Aquatic Wildlife

a. General

Large indigenous populations of salmon and trout have always been the principal species of aquatic wildlife utilized by man in Oregon. Native production of salmon and trout has decreased drastically in the last century due to irrigation, agriculture, logging, pollution, and elimination of entire races of anadromous fish by water projects that blocked fish from hundreds of miles of productive habitat (Craig and Hacker, 1940, p. 191-194; Gharrett and Hodges, p. 7-25; Cleaver, p. 88; and Pacific Northwest River Basins Commission, 1969, p. I-9 and p. II-194-198, and 1971, p. 11 and 23-29). To compensate for decreasing natural production, intensive artificial propogation programs by State and Federal fishery agencies have been implemented in recent years. This increased hatchery production of salmon and trout is making substantial contributions to the fisheries.

Distribution of fishes of Oregon, as described in this statement, are based primarily on Bond (1973), reports of the Pacific Northwest River Basins Commission (1969 and 1971), and 12 Basin Investigation reports and Annual Reports of the Fishery Division (1964-70) of the Oregon State Game Commission. Common and scientific names are those recommended by the American Fisheries Society (Bailey).

Certain species of fish are classified as "game fish" by law (Oregon Game Code, p. 7). Fish in Oregon are generally grouped into the following five categories; anadromous fish, cold-water game fish, warm-water game fish, non-game or rough fish, and surf and bay fish.

(1) Anadromous Fish - Species hatched in freshwater that migrate as young fish to the Pacific Ocean to grow and mature and return to freshwater to spawn. These include salmon, steelhead, cutthroat trout, sturgeon, striped bass, shad, smelt and lamprey. Anadromous fish that occur in all sub-biomes, except the Juniper sub-biome are Chinook salmon (Oncorhynchus tshawytscha), Coho salmon (Oncorhynchus kisutch), Sockeye salmon (Oncorhynchus nerka), Rainbow trout (steelhead) (Salmo gairdneri), White sturgeon (Acipenser transmontanus), American shad (Alosa sapidissima), Pacific lamprey (Entosphenus tridentatus).

The majority of the salmon and steelhead are produced in the Northwest Coastal Forest, but fairly large runs enter some streams in Montane Forest. Fish originating in the Snake River system migrate through four biomes while in the Columbia River (Figure). Annual counts of anadromous and resident species are made at each mainstem dam (U.S. Army Corps of Engineers, 1969).

(2) Cold-Water Game Fish - All trout, kokanee, whitefish and mullet. Native fish include rainbow trout, cutthroat trout, Dolly Varden, Kokanee, whitefish and mullet. Introduced fish include brook, brown, lake and golden trout and Atlantic salmon. Species that are found in all sub-biomes (either native or introduced) include rainbow trout (Salmo gairdneri), cutthroat trout (Salmo clarki sp.), brown trout (Salmo trutta) and kokanee (Oncorhynchus nerka kennerlyi).

Various subspecies of both rainbow and cutthroat trout have been reared in hatcheries and at one time or another planted in most easily accessible waters of the state to improve angling.

Dolly Varden trout (Salvelinus malma) and mountain whitefish (Prosopium williamsoni) are found in all sub-biomes except the Broad Sclerophyll. Brook trout (Salvelinus fontinalis) occur everywhere except in the Palouse Prairie sub-biome.

Cold-water game fish require cold water temperatures (below 70°F) and the best water quality to maintain healthy populations. They are most numerous in streams and lakes of the Coniferous Forest, but occur in all biomes and sub-biomes where habitat is suitable. Young salmon and steelhead require the same water quality conditions that cold-water game fish prefer.

Some resident trout, kokanee, whitefish, mullet and lampreys exhibit seasonal intra-stream migrations for spawning in many stream and lake systems. Since this is a critical requirement of these species, migration routes should not be blocked by obstructions.

Young trout and salmon are primarily insect feeders. As they grow and become larger, a greater variety of organisms are eaten, including crustaceans and terrestrial insects that fall into streams. Mature individuals become quite predaceous on small fish, especially lake, Dolly Varden and brown trout. An abundant population of salmonid species is therefore dependent upon a healthy food chain consisting of many small animals that feed on aquatic plants. Good quality water and habitat conditions are essential to maintain the food chain.

(3) Warm-Water Game Fish include bass, sunfish, catfish, crappie and perch (all introduced in late 19th century). Species now common to all sub-biomes are largemouth bass (Micropterus salmoides), brown bullhead (Ictalurus nebulosus). Species found in all sub-biomes except the Juniper are: Yellow perch (Perca flavescens), Bluegill (Lepomis macrochirus), Pumpkinseed (Lepomis gibbosus), White crappie (Pomoxis annularis), Black crappie (Pomoxis nigromaculatus). Smallmouth bass (Micropterus dolomieui) occur in all sub-biomes except the Broad Sclerophyll. Channel catfish (Ictalurus punctatus) are now found in all sub-biomes except the Juniper and Broad Sclerophyll.

Warm-water game fish have been widely introduced throughout the state in all types of aquatic habitat. These species require warmer water temperatures (75°- 85° F) than trout for reproduction. They are also more tolerant of adverse habitat conditions than are salmon and trout, e.g., lower dissolved oxygen concentrations or increased turbidity. They are more prolific than cold-water species and usually cause fishery management problems when introduced into waters managed for trout or salmon production. Because they will thrive in a wide range of habitat conditions and degraded waters, these species provide recreation in some waters unsuited for cold-water fishes.

(4) Non-Game or Rough Fish include suckers, dace, sculpins, squawfish, carp, chiselmouth, chubs (roach) and some lampreys. Species found in all sub-biomes are Redside shiner (Richardsonius balteatus), Largescale sucker (Catostomus macrocheilus), Bridgelip

sucker (Catostomus columbianus), Northern squawfish (Ptychocheilus oregonensis), Tui chub or roach (Gila bicolor). Chiselmouth (Acrocheilus alutaceus) are in all sub-biomes except the Broad Scherophyll. Dace (Rhinichthys) and sculpins (Cottus) are distributed throughout the state. Carp (cyprinus carpio) have been introduced into all sub-biomes except the Juniper.

Native species like shiners, dace, suckers, chubs and squawfish, and the introduced carp can cause serious management problems to fishery managers. Populations of non-game fish tend to "explode" and overpopulate waters being managed for game fish. In many waters, non-game fish are too competitive (especially for cold-water species), particularly if habitat and water quality conditions are being degraded. Endemic non-game fish are also of scientific interest.

(5) Surf and Bay Fish include seaperch, rockfish, greenling, flounder, hering and smelt. These fish are all limited to marine habitat and will be discussed under the section on the Northwest Coastal Forest.

(6) Rare and Endangered Fish - More species are considered rare or endangered by the State of Oregon (Shay, p. 7; Miller, p. 249; and Bond, 1966) than by the Bureau of Sport Fisheries and Wildlife (BSF&W, 1968). The only species on the national list is Lahontan cutthroat trout (Salmo clarki henshawi) listed as rare. Its peripheral range is in southeastern Oregon. Hatchery fish have been

planted in several lakes of Malheur and Harney Counties. Species listed by the State of Oregon are:

Alvord cutthroat trout (Salmo clarki subsp.)

Endangered. Present range is two streams in Malheur County.

Redband trout (Salmo sp.)

Rare. Found in several streams in Harney and Lake Counties.

Warnersucker (Catostomus warnerensis)

Rare. Warner Valley

Shortnose sucker (Chasmistes brevirostris)

Rare. Klamath Basin.

Alvord chub (Gila alvordensis)

Endangered. Alvord Basin (Hubbs, 1972)

Millicoma dace (Rhinichthys sp.)

Endangered. Coos River

Pit sculpin (Cottus pitensis)

Peripheral. May be extinct in Oregon. Numerous in California.

Malheur Sculpin (Cottus bairdi bendirei)

Rare. Harney Basin

California roach (Hesperoleucus symmetricus)

Rare. Goose Lake Drainage

Pit-Klamath brook Lamprey (Lampetra lethophaga)

Rare. Klamath and Pit drainages and Goose Lake.

Walleye (Stizostedion vitreum vitreum) were introduced in the upper Columbia River and are occasionally taken from the middle Columbia River. Burbot (Lota lota) is another northern fish that is uncommon in the Columbia River below McNary Dam.

Fish are usually considered the most important group of aquatic life because of their direct use to man. However, there are many other aquatic animals that are important because they either provide minor direct benefits to man or contribute to the aquatic food chain and other complex ecological relationships in aquatic ecosystems. Some of the more important groups include:

Crustacea - shrimp, crayfish and crabs.

Pelecypoda - clams, oysters and mussels.

Insecta - mayflies, stoneflies and caddisflies.

In 1970, over 40,600 pounds of bay and razor clams, 39,000 pounds of crayfish and 6,300 pounds of ghost shrimp (callianassa) and mud shrimp (upogebia) were processed through commercial channels in Oregon (Fish Commission of Oregon, 1971). Populations of bay and razor clams support very intensive sport digging. In many waters of the state, people catch crayfish to eat, and sport fishermen commonly catch shrimp for fish bait.

b. Northwest Coastal and Montane Forest Sub-biomes

The two coniferous forest sub-biomes cover the largest area in Oregon. They produce most of the state's water supply, which is generally of high quality in mountainous areas. Most streams and rivers produce near neutral water of low temperatures and a fair number of aquatic animals. However, significant changes in water quality may occur at lower elevations. Water temperatures often increase substantially during the summer low flow period and water quality if further degraded by pollutants. Extreme water withdrawals for irrigation contribute to

higher temperatures and dry stream beds in many cases throughout the biome. These habitat changes are deleterious to trout and salmon but beneficial to populations of warm-water and non-game species.

Historically, some of the best anadromous fish habitat on the west coast of North America was located in these sub-biomes. The Rogue, Umpqua and Willamette Rivers and Tenmile Lakes are notable examples. Other coastal rivers like the Nehalem, Nestucca, Alsea, Coos and Tillamook Bay streams also produce large numbers of fish. In eastern Oregon, parts of the Deschutes, John Day and Grade Ronde rivers contributed many fish to the various fisheries. Deleterious habitat changes, introductions of warm-water and non-game fish, and blocked access (primarily by dams) to many miles of streams have each caused reductions in the runs.

Salmon and anadromous trout are still widespread throughout the biome, occurring wherever their access is not blocked by impassable obstructions - either natural (water falls) or man-made (dams or log jams). Because of the life requirements of anadromous fish, special efforts are needed to keep migration routes open and water of good quality on the spawning grounds for remaining populations.

Other aquatic organisms, as well as fish, have adapted to good quality water, food and cover. Most organisms of this biome require stream habitat that is relatively free of fine salt, sand or clays. Benthic organisms, crustaceous and aquatic insects require larger substrate like rubble and gravel. Clean, silt-free gravel is

important to many organisms and especially for salmon and trout spawning. Gravel between 1/2 to 5 inches in diameter is needed, depending on the species. Hatching success is drastically reduced by heavy sedimentation of spawning areas.

The following water requirements are considered optimum for aquatic life in the biome:

Water temperature - 50^{o} to 60^{o} F. (summer)

Dissolved oxygen - 7 to 9 ppm.

Hydrogen Ion (pH) - 6.8 to 7.8 ppm.

Total Dissolved solids - 150 ppm.

Jackson Turbidity Units - 5 or less (summer)

Smaller organisms such as aquatic insects are less tolerant to water quality changes than many fish.

Adequate streamside vegetation is very important to the aquatic ecosystem. It stabilizes streambanks preventing erosion and sedimentation. Vegetation provides protective cover for fish and other life. It also shades the stream which is a key factor in maintaining the low water temperature characteristic of most streams in the biome.

There are also many important fish-producing lakes or reservoirs in the biome. These waters are generally more fertile than rivers and streams unless the basins lose their nutrients by periodic flushing. With intensive management, some lakes like Diamond, East and Paulina consistently produce hundreds of thousands of trout annually.

Most important aquatic species in these sub-biomes have already been mentioned, and will be discussed further. Three unique introductions by the Oregon State Game Commission into lakes in these sub-biomes are Atlantic salmon (salmo salar), Lake trout (salvelinus namaycush) and Golden trout (Salmo aguabonita). Although these three species were released into some high cascade lakes in western Oregon, the successful plants and populations are in lakes in eastern Oregon (Montane Forest sub-biome).

c. Northwest Coastal Forest

Although native runs of anadromous fish have been greatly reduced from historic levels, natural production in this sub-biome is still vital to various fisheries in Oregon. Fish produced in freshwater are caught as adults in the Pacific Ocean, estuaries and main river systems. Coastal lakes provide habitat for salmon, trout and warm-water game fish. There are numerous reservoirs in the Willamette system now creating habitat for various species, depending on the characteristics of each reservoir.

The most important anadromous species are Chinook and Coho Salmon, and steelhead and coastal cutthroat trout (Salmo clarki clarki). Chum salmon (oncorhynchus keta) spawn in tributaries to the lower Columbia River and in many coastal rivers in decreasing numbers in central and southern Oregon. Pink salmon (oncorhynchus gorbuscha) enter the lower Columbia Rivers and occasionally stray into coastal streams.

Both white and green sturgeon (Acipenser medirostris) inhabit the lower Columbia River and lower reaches of coastal rivers and some lakes. Green sturgeon seldom migrate above tidewater. Shad and striped bass (Morone saxatilis) also occur in some larger coastal rivers and the Columbia River.

Large runs of Columbia River smelt (Thaleichthys pacificus) enter the Columbia River annually and occasionally the Sandy River and some coastal streams. This species does not migrate over Bonneville Dam. The Pacific lamprey enters most coastal rivers as well as the Columbia River.

Resident rainbow and cutthroat trout are common to the sub-biome. Kokanee have been stocked in many reservoirs. Whitefish are found in colder streams and some reservoirs at higher elevations in the Cascade Mountains. Brown, eastern brook and Dolly Varden trout are limited to a few specific areas.

Warm-water game fish include largemouth and smallmouth bass, yellow perch, bluegill, pumkinseed, white and black crappie, channel catfish, brown bullhead, yellow bullhead (Ictalurus natalis), green sunfish (Lepomis cyanellus), and warmouth (Lepomis gulosus).

Non-game fish in the sub-biome are redside shiner; largescale, bridgelip, and mountain sucker (Catostomus platyrhynchus); northern squawfish and Umpqua squawfish (Ptychocheilus Umpquae); roach; chiselmouth; carp; tench (Tinca tinca); Oregon chub (Hybopsis crameri); sandroller (Percopsis tranmontana); mosquite fish (Gambusia affinis);

Peamouth (Mylocheilus caurinus); Speckled dace (Rhinichthys osculus carringtoni); Blackside dace (Rhinichthys osculus nubilus), Leopard dace (Rhinichthys falcatus) and Umpqua Dace (Rhinichthys evermanni); Coastrange sculpin (Cottus aleuticus), Prickly sculpin (Cottus asper), riffle sculpin (Cottus gulosus), Torrent sculpin (Cottus rhotheus), Reticulate sculpin (Cottus perplexus) and Shorthead sculpin (Cottus confusus); Three-spined stickleback (Gasterosteus aculeatus); and river Lamprey (Lampetra ayresi) and western brook lamprey (Lampetra richardsoni).

The Oregon chub is the only Hybopsis native to the Pacific Coast. Other non-game fish with a restricted distribution are the Umpqua dace (Umpqua River and tributaries) and the Umpqua squawfish (Umpqua and Siuslaw Rivers and intervening waters). The rare Millicoma dace is found only in the Coos River.

The commercial fishery for crayfish is primarily conducted in this sub-biome, with the catch composed of two subspecies - Pacifastacus leniusculus leniusculus and P.I. trowbridgii (Miller and Van Hyning, p. 79).

Estuaries or bays are located along the Oregon coast at the mouth of larger rivers (Wick, p. 7). These tidal areas where salt and freshwater mix are very productive habitats for many aquatic species (BSF&W, p. 5, 1968 and p. 19-27, 1971). Estuaries are breeding and nursery grounds for many species of fish and other aquatic life.

Oregon's major bays have been heavily industrialized and serve as harbors for shipping and commercial and sport fishing

fleets. Sandy beaches and rocky shorelines provide exceptional recreational opportunities, including fishing and clam digging.

The following fish, excluding anadromous species, are caught by anglers in estuaries or in the surf (OSGC & USF&WS, p. 9, 1968):

Embiotocidae - Sea or surf perches

Plueronectidae - Flounders

Hexagrammidae - Greenlings. Kelp greenling (Hexagrammus decagrammus) and Lingcod (Ophiodon elongatus)

Scorpaenidae - Rockfishes

Cottidae - Sculpins, Pacific staghorn sculpin (Leptocohus armatus) and Red irish lord (Hemilepidotus hamilepidotus)

Clupeidae - Pacific herring (clupea harengus pallasi)

Engraulidae - Northern Anchory (Engraulis Murdax)

Osmeridae - Smelt, both Columbia River smelt and surf smelt (Hypomesus pretiosus)

Dungeness crabs (Cancer magister) are numerous in most bays and they are eagerly sought as a sport catch. This species also supports an important commercial fishery which landed nearly 15 million pounds of crabs in 1970 (FCO, 1971). The native oyster (ostrea lurida) and Japanese oyster (Crassostrea gigas) are cultured by private oyster growers in some estuaries. Razor clams (siliqua patula) are abundant on the Clatsop County beaches. Only a few isolated populations of razor clams occur on other beaches. Bay clams are abundant in certain areas of some coastal bays (Marriage, 1954). Important species are the

gaper clam (Schizothaerus nuttalli), cockle (Clinocardium nuttalli), softshell clam (Mya arenaria), butter clam (Saxidomus giganteus), and Littleneck clam (Protothaca staminea). Ghose and mud shrimp are dug for fish bait.

The eelgrass plant community is very important to some species of fish, gaper clams, and crustacea (BSF&W, p. 6 & 8, 1968). Important aquatic habitat in estuaries has been degraded or lost by dredging and spoiling, construction of industrial structures, accelerated sedimentation, and by domestic and industrial pollution (Wick, and BSF&W, p. 14, 1968 and p. 56-80, 1971).

Many invertebrate animals inhabit rocky intertidal areas along the Oregon coast. Observing and collecting animals in tide pools is a favorite activity of many people. The California mussel (Mytilus Californianus) was eaten by Indians, but few people now eat this species. Instances of people eating mussels during summer months and becoming sick from paralytic poisoning probably discouraged much use of this species as food. Other conspicious representative animals of the rocky shores and tide pools are Acron barnacle (Balanus glandula), Goose-neck barnacle (Pollicipes ploymerus), Keyhole limpet (Diodora aspera), Periwinkle snail (Littorina scutulata), Gumboot chiton (Cryptochiton stelleri), Hermit crab (Pagurus hirsutiusculus), Common star (Pisaster orhraceous), Green anemone (Anthopleura xanthogrammica), Purple sea urchin (Strongylocentrotus purpuratus), Kelp crab (Pugettia producta) (FCO, 1970, pp. 24-33).

d. Montante Forest

Rivers flowing from the Montane Forest originate in the Cascade, Ochoco, Aldrich, Strawberry, Blue and Wallowa Mountains. Melting snow generally provides excellent quality water to the upper reaches of the Rogue, Deschutes, John Day, Grande Ronde and Imnaha Rivers. Important salmon and steelhead runs are still produced by these rivers. Water quality and quantity are reduced by man's many activities and uses of water so that habitat conditions gradually deteriorate as flows leave the Montane and reach lower elevations in other sub-biomes. Many beautiful lakes and reservoirs are scattered throughout the sub-biome, especially in the Cascades.

Cold water fish species are abundant at higher elevations where water quality is good. High populations of aquatic insects, crustaceans and clams are also present in these waters. A transition zone between cold- and warm-water fish usually occurs at lower altitudes before streams leave the biome. Here water temperatures become increasingly warmer during low summer flows.

Water temperatures above 70^{o}F and excessive sedimentation are generally the two factors that cause the greatest reductions in populations of salmonid species. Many land management practices increase the silt load of streams, and excessive irrigation withdrawals further reduce the productive capacity of aquatic habitat.

Anadromous fish native to the Montane Forest include chinook, coho and sockeye salmon; steelhead; sea-run cutthroat; white

sturgeon; and the Pacific lamprey. Shad are present in the Columbia and Rogue Rivers. Native trout are rainbow, Dolly Varden, and the yellowstone cutthroat trout (salmo clarki lewisi) found in Snake River tributaries and some streams in the John Day system (Grant County). Kokanee and whitefish are also indigenous to the sub-biome. The redband trout occurs in several tributaries of the Silver Lake and Harney basins.

Eastern brook and brown trout are widely introduced. Good populations of lake trout are present in O'Dell, Big Cultus and Crescent Lakes, Golden trout occur in Razz, Wood, and Hobo Lakes in the Wallowa Mountains and several high Cascade lakes in central Oregon. Atlantic salmon have been planted in several central Oregon lakes, but this species has done well only in Hosmer Lake. Atlantic salmon have also been planted in Olive Lake southeast of Dale. The Lost River sucker (Castostomus luxatus) or "mullet" inhabits only the Klamath Basin.

All warm-water game fish listed for the Northwest Coastal Forest, except the warmouth, are also in parts of the Montane Forest.

Non-game fish are numerous in the sub-biome. The shortnose sucker (Chasmistes brevirostris) is native to only the Klamath Basin, and is considered a rare species as is the Pit-Klamath brook lamprey also found in this basin. A landlocked form of the Pacific lamprey lives upper Klamath Lake. The mountain, bridgelip and largescale suckers are widespread in the sub-biome, and the Klamath

smallscale suckers (Catostomus rimiculus) is present in the Rogue River. Another sucker native to the Klamath basin is the Klamath largescale sucker (Catostomus synderi). Other non-game fishes with wide distribution are the redside shiner, carp, roach, squawfish and chiselmouth.

Dace present in the sub-biome are speckled, Leopard, Umatilla (Rhinichthys osculus umatilla) and Longnose dace (Rhinichthys cataractae). The blue chub (Gila coerulea) is native only to the Klamath system. The western brook lamprey and three-spined stickleback live in the Rogue River.

The coastrange, prickly, torrent, reticulate and shorthead sculpins are in this sub-biome. The slender sculpin (Cottus tenuis), Klamath Lake sculpin (Cothus princeps) and marbled sculpin (Cottus klamathensis) are indigenous to only the Klamath Basin. The mottled sculpin (Cottus bairdi), Piute sculpin (Cottus beldingi) and margined sculpin (Cottus marginatus) complete the cottids of the Montane Forest.

e. Cold Desert

Water is a precious commodity in many parts of the Cold Desert. Most surface water originates at higher elevations. The majority of the smaller streams are ephemeral and unreliable sources of water. Competition for water is intense among agricultural, industrial, domestic and wildlife uses. Many reservoirs of all sizes are constructed to store and conserve water for these uses.

More rare and endangered fishes occur here than any other sub-biome because of the harsh environmental conditions and isolated watersheds. The entire population of a species may be confined to one small spring creating a very precarious situation for survival. A series of drought years or other adverse habitat change could eliminate a species and be disasterous to populations of other aquatic animals that are barely existing under normal condition in the desert.

The Cold Desert encompasses most of southeastern Oregon, a small area south of Klamath Falls, and a narrow extension along the Lower Deschutes River northward into Central Washington. Aquatic habitat consists of major rivers, streams, lakes, reservoirs, springs, marshes and pot holes. A wide range of water quality exists among areas and types of habitat. Some lakes are very alkaline. Abert Lake, for example, is so saturated with carbonates and dissolved solids (sodium and chloride) that fish cannot survive in the lake. Only brine shrimp, brine flies and some plankton can tolerate the "salty water" of Abert Lake.

The Cold Desert is characterized by warm summers and cold winters so fish must be able to withstand extreme temperatures in some habitats. Water temperatures are the critical factor governing the distribution of cold water fishes in much of the sub-biome. Serious erosion of streambanks and overgrazing of watersheds has resulted in extensive sedimentation of many rivers. This erosion has resulted

in the loss of much of the original productivity of many streams. Adequate bank cover of grasses, sedges, shrubs and trees is essential to maintain habitat for cold-water species.

The Owhyee and Malheur Rivers once produced large runs of salmon and steelhead, but construction of dams and other habitat alterations eliminated these runs (PNWRBC, p. 11, 1971). Runs to Crooked River (tributary to Deschutes River) were also eliminated in this way. The Deschutes River has significant populations of chinook and steelhead and a few coho. These species, sockeye, shad and Pacific lamprey migrate up the Columbia River through the Cold Desert. White sturgeon also use the Columbia River in this sub-biome.

Rainbow, cutthroat, brook, brown, Dolly Varden, kokanee and whitefish live in suitable habitat. Fisheries in many lakes, reservoirs and streams are maintained by hatchery stocking of primarily rainbow but some cutthroat. The rare Lahontan cutthroat trout has been planted in several lakes in Harney and Malheur Counties. The endangered Alvord cutthroat trout is found only in Whitehorse and Willow creeks. The Bureau of Land Management, Oregon State Game Commission, and Whitehorse Ranch are now cooperating on a habitat improvement project to increase the populations of alvord trout by improving habitat conditions. Populations of another rare species, the redband trout, occur in several streams in Harney County.

Other rare fish are the Warner sucker (Warner Valley), Alvord chub (Alvord Basin), Pit-Klamath brook lamprey (Goose Lake) and the Pit sculpin which was once collected in tributaries to Goose Lake

but now may be extinct in Oregon. This sculpin has an undetermined status in California. The California roach is found in Oregon only in the Goose Lake drainage, which may be peripheral range.

Warm-water game fish reported from the Cold Desert include largemouth and smallmouth bass, yellow perch, bluegill, pumpkinseed, white and black crappie, channel catfish, Brown bullhead and black bullhead (Ictalurus melas).

Non-game fish are redside shiner, carp, roach, squawfish, chiselmouth and the tadpole madtom (Noturus gyrinus) in the Owyhee River. There are also four species of dace, six different sculpins, and nine sucker species (excluding the warner sucker) in the sub-biome.

f. Juniper

Anadromous fish are not present in this sub-biome because water projects blocked access to spawning areas in upper Crooked River. Rainbow, cutthroat, brook, brown, Dolly Varden, kokanee and whitefish inhabit cooler waters of the sub-biome. Other fish include largemouth and smallmouth Bass, redside shiners, Brown bullheads, suckers, sculpins, dace, roach, squawfish and chiselmouth.

The Donner and Blitzen and Crooked rivers are the two largest in the sub-biome. Tributaries to the Blitzen are small but have good quality water. Stream flows get very low in Crooked River above Prineville reservoir and water temperatures are high during summer months. Water quality below Prineville has been degraded in

recent years due to accumulation of suspended material in the reservoir which causes a turbidity problem.

g. Broad Sclerophyll

All fish occuring in the Broad Sclerophyll have already been mentioned in the section describing fishes of the Montane Forest. The Upper Klamath Basin is not considered part of the Broad Sclerophyll. The following list is repeated for convenience of reference to species of this sub-biome.

Anadromous fish:

Chinook, coho, steelhead, cutthroat trout, shad, white sturgeon and Pacific lamprey.

Resident cold-water game fish:

Rainbow, cutthroat, brook, brown and kokanee.

Warm-water game fish:

Largemough bass, bluegill, pumpkinseed, green sunfish, white and black crappie, and brown bullhead.

Non-game fish:

Suckers - largescale, bridgelip and Klamath smallscale.

Minnows - carp, squawfish, redside shiner, roach, blackside and speckled dace.

Sculpins - coastrange, prickly, and reticulate; and three-spined stickleback and western brown lamprey.

h. Palouse Prairie

Characteristics of rivers in this grassland sub-biome generally include low gradients, warm summer water temperatures and fairly wide channels. Most water originates in the Montane Forest where

water is at its highest quality. Water quality usually becomes degraded as it flows through the grassland biome. Warm-water species predominate over salmonids as water temperatures and sedimentation increase at lower elevations. Salmon and trout are found where habitat conditions are suitable, but some streams, lakes, and reservoirs are marginal or unsatisfactory habitat for cold-water species. The same kinds of aquatic animals typical of other biomes (insects, mussels and crustaceans) also occur in this sub-biome.

In northeastern Oregon parts of the following major rivers flow through the Palouse Prairie sub-biome.

- John Day. Above Prairie City to the Columbia River.
- Umatilla. Majority of the watershed.
- Grande Ronde. La Grande to below Elgin.
- Wallowa. Joseph to Wallowa and northeast.
- Powder. Middle and lower reaches.
- Burnt. Middle and lower reaches.
- Snake River. Huntington to below Oxbow Dam.
- Columbia River. Between Deschutes and John Day Rivers.

Some fairly large reservoirs are located within this sub-biome, e.g., Malheur, Thief Valley and McKay reservoirs.

A small isolated area in the Bear Creek and Rogue River valleys in southwestern Oregon is also calssified as Palouse Prairie. Since this sub-biome intermingles with the Broad Sclerophyll, refer to the species listed under the Broad Scherophyll for those fishes present in this part of the Palouse Prairie sub-biome. Warm-water

temperatures, pollution, and irrigation withdrawals cause serious water quality problems for cold-water species during summer months in Bear Creek and other tributaries to the Rogue River.

Anadromous fish were eliminated from the Powder and Burnt Rivers by water projects. Large numbers of salmon and steelhead migrate through the sub-biome enroute to major spawning and rearing areas in the Montane Forest. The same species of anadromous fish discussed under the Cold Desert sub-biome occur in the Palouse Prairie.

Substantial runs of chinook and steelhead occur in the John Day, Grande Ronde and Wallowa Rivers. Smaller numbers of steelhead spawn in the Umatilla system.

Rainbow, cutthroat, Dolly Varden and brown trout are present where habitat conditions are good. Kokanee and whitefish occur in some waters. Warm-water game fish are numerous in most rivers, lakes and reservoirs where they have been introduced. They include: largemouth and smallmouth bass; yellow perch; bluegill; pumpkinseed; white and black crappie; channel catfish; and brown, yellow, and black bullheads. Non-game fish are redside shiner, carp, roach, squawfish, chiselmouth, two suckers, four dace and five sculpins.

No rare fish species inhabit the Palouse Prairie sub-biome in Oregon.

3. <u>Domestic Livestock</u>

a. <u>Palouse Prairie</u>

Grazing by domestic livestock occurs throughout the Palouse Prairie sub-biome on those areas that have not been converted to crop production. Major use is by cattle with lesser amounts by sheep. In addition, a few horses graze as a part of established livestock operations. Some minor use is made in connection with recreational and other activities.

At present domestic livestock grazing is the most important direct economic activity on the uncultivated native rangelands. While some operators depend completely on private lands others employ a combination of native range and private land to complete a year around operation. Use of the native range is generally made during the period April to October. Ranch pasture and forage supplies are used during the remaining months.

Grassland types are most valuable for beef cattle production while shrub types are best utilized by sheep. Important grass species used by cattle are blue bunch wheatgrass, Idaho fescue, needlegrass, sandberg bluegrass, and junegrass. In addition to the various grass species, sheep use big sagebrush, bitterbrush, rabbitbrush, threetip sage, hopsage, and other shrubs.

In the southwestern Oregon area, cattle use considerable medusahead - rye in the early spring when it is most palatable and nutritious. The general trend in cattle numbers is upward while sheep

are declining in the Palouse Prairie.

b. Cold Desert

The Cold Desert produces a variety of forage species highly desirable for domestic livestock production. Livestock ranching is the dominant economic enterprise in the area and cattle graze throughout. Although large numbers of sheep grazed in the past they have declined drastically and now use only relatively few areas. Scattered bands of horses also graze throughout the area. Some are authorized to use public lands, some graze in trespass and others are wild free roaming.

Public Law 92-195 passed in 1971 provides for the protection, management, and control of wild free roaming horses and burros on public lands. Wild horses have established themselves in the cold desert biome and the regulations provide for the maintenance of strong, healthy herds in a quality habitat.

Throughout the Cold Desert there is a close tie between agricultural cropland and rangeland. Ranchers graze the native ranges with their domestic livestock generally within the period April to October. They complete their year around operation by using ranch forage supplies during the winter months. The interdependance of crop and rangelands makes the use of native range by livestock of vital importance to the economy.

In the past, continuous season long livestock grazing resulted in serious deterioration of the vegetation and soil resources. Extensive areas were invaded with sagebrush and undesirable annual grasses

and weeds. Consequently, soil productivity and vegetation related resource values declined. In recent years it has become increasingly important to insure these values are protected and improved. This is done through range rehabilitation projects and the application of intensive grazing management practices. Because grass is valuable for beef cattle production and watershed protection, substantial acreages of sagebrush have been either plowed and seeded to crested wheatgrass or sprayed to remove the sagebrush competition. These land treatment areas must receive intensive management in conjunction with the surrounding native range areas. Many livestock now graze in accordance with carefully prepared management plans developed to improve watersheds, maintain and improve wildlife habitat, and provide additional livestock forage.

c. Juniper

The Juniper sub-biome falls within the boundary of the Cold Desert where ranching is the dominant economic enterprise. Grazing use therefore is made in conjunction with and essentially the same as in the Cold Desert. (Refer to Domestic Livestock - Cold Desert.) Cattle, sheep, and some horses graze as part of established operations generally within the period from April to October. Year around livestock operations are completed by using additional forage supplies during the winter months.

Juniper types produce a variety of forage plants valuable for domestic livestock, however, quantity is low due to past heavy grazing practices and generally unfavorable growing conditions. As a result, more acres are required to support an animal unit month of grazing than in most other native range vegetation types.

d. Broad Sclerophyll

Domestic livestock graze generally throughout the Broad Sclerophyll in the more open and sparse timber and brushland areas. Predominate grazing use is by cattle with lesser sheep and some horse use made in connection with established livestock operations, part-time ranching enterprises and other activities. A wide variety of vegetation is present in this sub-biome. Included are many of the plants present in the Northwest Coastal Forest, Palouse Prairie, Cold Desert and Montane Forest sub-biomes. Considerable Medusa head rye is present which is not of significant importance in the other biomes. Cattle use this plant species heavy in the early spring when it is most palatable and nutritious.

e. Northwest Coastal Forest

Grazing by livestock occurs throughout the Northwest Coastal Forest in open areas and sparse timbered stands where water and desirable forage species are present. Cattle, sheep and a few horses graze these areas as part of established livestock operations. In addition, some relatively minor grazing use is made in connection with recreational activities. Most livestock use occurs between April 1 and October 31.

Domestic livestock utilize a wide variety of plant species. Some of the more common are: Blue wild-rye (Elymus glaucus), Kentucky bluegrass (Poa pratensis), tufted hairgrass (Deschampsia caespitosa) and Mountain bromegrass (Bromus marginatus). The diet of

domestic grazing animals consists primarily of grass and forb species in the spring and early summer months. As the season progresses these plants mature and grazing use shifts more to browse species which maintain a higher protein content during the late summer and fall.

f. Montane Forest

Grazing by livestock occurs throughout the Montane Forest in open areas and sparse timbered stands. Cattle, sheep and a few horses graze as part of established livestock operations. In addition, some minor grazing use is made in connection with recreational activities. Most rangelands in the Montane Forest provide 4 to 5 months of grazing. Additional forage sources are required to complete year around livestock operations.

Grassland openings intermingled with forested grasslands make up less than one-fourth of the range area yet it provides nearly half the available forage. In the open areas livestock principally utilize bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass and onespike outgrass. In the sparse timber lands livestock use various grass species in the bunchgrass, pine-bunch grass and pine grass-elk sedge communities.

I. Micro and Macro Organisms

1. Soil Organisms

Wilde (1958) summarizes the importance of soil organisms by stating they are essential to the existence of plants and animals. Organisms are a vital part of the cyclic pattern of matter in nature and are the tools with which nature fashions soil from lifeless geologic matrix and plant and animal residue.

Organisms in the soil may be classified as saprophytes or parasites. Saprophytes break down dead organic material while parasites attack living material. Soil organisms may also be grouped as being heterotrophs or autotrophs. Heterotrophs obtain carbon and energy from organic matter. Autotrophs obtain carbon from CO_2 and energy from the sun (photoautotrophs) or from chemical reactions (chemoautotrophs). The indigenous populations are termed autochthonous while the fluctuating populations are termed zymogenous.

Soil inhabiting microorganisms are the viruses, protobacteria, bacteria, actinomycetes, and fungi. Viruses are all parasitic and protobacteria are parasitic upon bacteria. There are about 10^8-10^9 bacteria per milliliter of soil. Heterotrophic bacteria are sensitive to temperature, organic matter, acidity, inorganic nutrients, soil disturbance, and organic carbon and O_2. Different types of bacteria thrive in different temperature regimes. The psychrophiles like temperature less than 20°C, mesophiles like temperatures from 25° to 35°C, and thermophiles like temperature from 45° to 65°C. Populations

bacteria are dependent upon the organic matter for survival. A neutral soil reaction (PH=7.0) is considered to be optimum. Sugars, starches, etc., are beneficial to growth. Soil disturbance incorporates organic matter into the soil or exposes it to the air where chemical oxidation may consume it. Bacteria populations drop fast below the surface soils.

Actinomycetes are autochthonous and the populations remain higher than bacteria in the subsoil. Streptomycetes are important as they fix nitrogen in root associations on non-leguminous species such as alder and snowbrush.

Fungi are heterotrophic and prefer a neutral soil reaction but have a broad range in pH tolerance. Fungi require O_2 while CO_2 is an inhibitor. Fungi may be separated into 5 groups depending upon their food supply. These groups are -- sugar fungi, lignin decomposers, copraphic, predaceous, and root inhabiting. The root inhabiting are very important and may be pathogenic or beneficial. Mycosrhiza fungi are very important for satisfactory growth of many species of trees. They make nutrients more available, dissolve primary minerals so plants may uptake them as nutrients, for all practical purposes, they enlarge the surface areas of roots and protect roots from pathogenic invasions.

Algea are photo autotrophs and are more important on bare ground than under heavy vegetation. Algea are self-supporting and some species fix nitrogen.

Lichens are algea-fungi associations. Lichens may be separated into crustose, foliose, or fruticose depending upon their morphology. Lichens do not compete with higher plants. Lichens are one of the prime organisms which start rock on its way to becoming soil. Higher plants more in after the lichens build up a suitable base for food and anchorage. Some lichens have the blue-green algea as partners and can fix nitrogen.

Protozo are single-celled animals which live in the soil. They are usually abundant if the soil fertility is low.

Multi-celled soil dwelling animals are as follows:

- Rotifers - feed upon plant debris.
- Roundworms - nematodes are an example. Nematodes need moisture to be active. Contrary to popular belief, about half the nematodes are saprophytes and are beneficial
- Annelid worms - earthworms fall into this group of animals. They secrete an alkaline solution containing amalase. Earthworms are killed when exposed to ultra violet light. Earthworms are important in incorporating litter into the soil.
- Vertibrates are mammals which burrough into the soil. Rabbits, marmots, etc., are examples. Moles, shrews, snakes, lizards and some birds also may be included.
- Arthopods are the insects, many live in the soil.
- Hexopods are 6-legged animals of which many live in the soil. A main stable of their diet is plant roots.

- Callembola - Springtails fall into th is group. They are saprophytes and may be considered the seagulls of the soil.
- Myriapods include the centipeds and millipeds.
- Octopods are 8-legged and include the spiders, mites, and ticks. Mites are responsible for the digestion of about 15% of the weight of new litter.

2. Aquatic Organisms

The aquatic environment varies with the size of the body of water, water velocity, temperature, mineral and organic nutrient constituents, turbidity, suspended sediment concentration, etc. In addition, the estuarine environment also varies according to tidal influences, salinity, etc. Organisms which may be found in great numbers in the stream environment are often not adapted to life within the lake or estuarine environments and vice versa. It is not possible to enumerate even the most important species of micro and macro-organisms for these varied aquatic environments because of 1) the number of species involved; 2) the diverse micro-environments throughout the state of Oregon; and 3) in many cases surveys of numbers and kinds of these organisms have been made for only small portions of a few bodies of water, usually for specific projects. Instead, this report will describe in very general terms the characteristics of broad groups of aquatic organisms.

a. The Ecosystem (EPA, Freshwater Biology, 1-8, 10, 11, 12)

(1) A food chain is the transfer of food energy from plants through a series of organisms with repeated eating and being eaten. Food chains are not isolated sequences but are inter-connected.

(2) A food web is the interlocking pattern of food chains in an ecosystem (Figure19). In complex natural communities, organisms whose food is obtained by the same number of steps are said to belong to the same trophic (feeding) level.

There are five basic <u>trophic levels</u>:

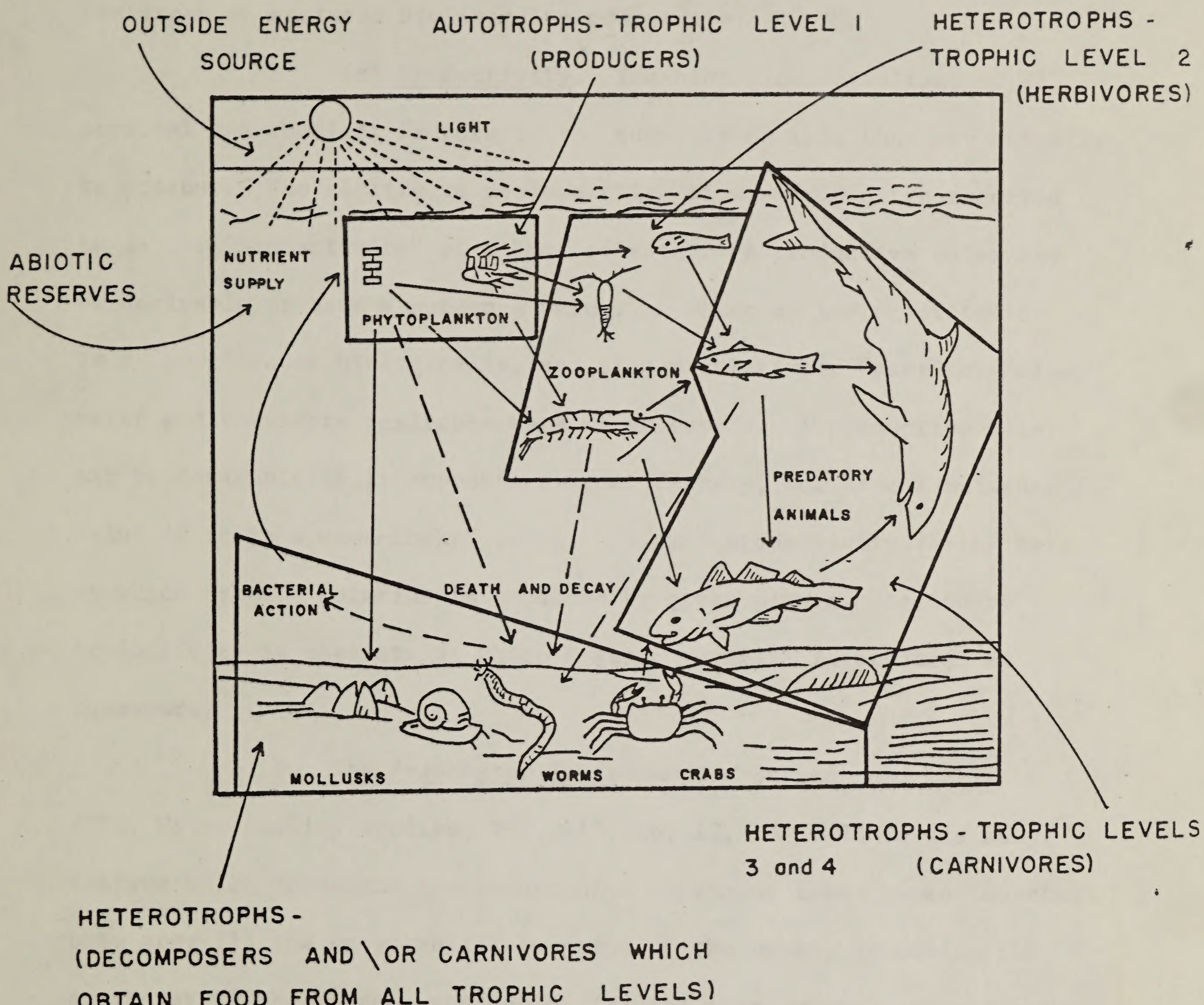
- <u>Green plants</u> (producers - See Figure 19) fix biochemical energy and synthesize basic organic substances.
- <u>Plant eating animals</u> (herbivores) depend on the producer organisms for food.
- <u>Primary carnivores</u>, animals which feed on herbivores.
- <u>Secondary carnivores</u> feed on primary carnivores.
- <u>Ultimate carnivores</u> are the last or ultimate level of consumers.

(3) <u>Plankton</u> are the microscopic and macroscopic animals, plants, and bacteria floating free in the open water. <u>Phytoplankton</u> are plant-like. These are the dominant producers of the waters, fresh and salt, "the grass of the seas". <u>Zooplankton</u> are animal-like. These include many different animal types from minute protozoa to gigantic marine jellyfish.

(4) <u>Periphyton</u> - The communities of microscopic organisms associated with submerged surfaces of any type of death. This includes bacteria, algae, protozoa, and other microscopic animals, and often the young or embryonic stages of algae and other organisms.

(5) <u>Benthos</u> are the plants and animals living on, in, or are closely associated with the bottom. They include plants and invertebrates.

(6) <u>Necton</u> are the community of strong agressive swimmers of the open waters. Certain fish, whales, and invertebrates such as shrimp and squid are included here.


OUTSIDE ENERGY SOURCE
AUTOTROPHS- TROPHIC LEVEL I (PRODUCERS)
HETEROTROPHS - TROPHIC LEVEL 2 (HERBIVORES)
LIGHT
ABIOTIC RESERVES
NUTRIENT SUPPLY
PHYTOPLANKTON
ZOOPLANKTON
PREDATORY ANIMALS
BACTERIAL ACTION
DEATH AND DECAY
MOLLUSKS
WORMS
CRABS
HETEROTROPHS - TROPHIC LEVELS 3 and 4 (CARNIVORES)
HETEROTROPHS - (DECOMPOSERS AND\OR CARNIVORES WHICH OBTAIN FOOD FROM ALL TROPHIC LEVELS)

(7) Marsh communities include the larger "higher" plants, floating and emergent. Both marine and freshwater marshes are areas of enormous biological productivity.

(8) Productivity. The biological resultant of all physical and chemical factors is the quantity of life that may actually be present. The ability to produce this "biomass" is often referred to as the "productivity" of a body of water. A productive water may be desirable or have a nuisance value. A water of low productivity is a "poor" water biologically, and also a relatively "pure" or "clean" water and therefore desirable as a water supply. A productive water may be desirable if it supports a trout fishery, but have a nuisance value if it is a weed-choked swamp. Primary productivity is the rate at which organic material is produced by green plants. Secondary productivity is the rate at which organic material is produced by consumers.

b. The Freshwater Environment - Streams and Lakes (EPA, Water Quality Studies, 2-1, -15, 16, 17, 18). There are many factors which determine the nature of a stream or lake. Some important ones are: (1) the geographical location of the basin, including the character of the bedrock and soils, (2) the size, shape, and general topography of the basin, (3) the character, amount, annual distribution, and rate of precipitation, and (4) the natural vegetative cover of the land which is responsive to the preceding factors and which is also subject to the activities of man. Natural vegetation is one of the major factors which determine runoff versus infiltration.

The productivity of a freshwater stream or lake is determined by a supply of adequate nutrients, light, suitable temperature, and time for growth to take place. Youthful streams, especially on rock or sand substrates are low in essential nutrients. Temperatures in mountainous regions are usually low, and the time for growth is low because of the steep gradients. Although ample light is available, growth of true plankton is greatly limited. Mature streams with relatively broad flood plains and slower velocities tend to accumulate more nutrients; the time for growth increases; water temperatures increase; and plankton flourish. On the other hand, a heavy load of silt would increase turbidity, reduce penetration of light, and plankton production would decrease. Streams which are approaching their base level, the sea or an estuary, exhibit ample time for growth but the balance between nutrient levels, turbidity, temperature and other seasonal conditions will determine overall productivity.

The productivity of lakes depends upon the size, shape, and depth of the lake basin; broad, shallow lakes with a tortuous shoreline are more productive than deeper, narrow lakes, with a minimum amount of shoreline. Generally, hard waters are more productive than soft waters with the most productive waters have a pH of 6.8 to 8.2.

The effect of the substrate on the productivity of streams and lakes is shown in Table I.

Table I

Effect of Substrate on Stream and Lake Productivity

Bottom Material	Relative Productivity* Streams	Lakes
Sand	1	1
Marl	6	-
Fine Gravel	9	-
Gravel and Silt	14	-
Pebbles	-	4
Coarse Gravel	32	-
Clay	-	8
Moss on Fine Gravel	89	-
Moss on Coarse Gravel	111	-
Watercress	301	-
Waterweed (anacharis)	452	-
Flat Rubble	-	9
Blcok Rubble	-	11
Shelving Rock	-	77

*Note: The productivity of sand bottoms is taken as 1.

c. Estuaries and Marshes (Ibid, p. 21-22, 27, 29, 31)

This discussion will include estuaries and marshes, freshwater, tidal, and saline inland marshes.

In general, environmental factors are more constant in freshwater and the ocean than in estuaries and salt marshes. Many factors are subject to change in estuaries and salt marshes; salinity, temperature, water elevation, vertical stratification, availability of nutrients, and turbidity. This complex interaction of physical and chemical factors determines the biotic composition of this environment. Generally, the number of species in this highly variable environment tends to be less than the number in a more stable environment. The dominant animal species (in terms of total biomass) which occur in estuaries are often transient, spending only a part of their lives in the estuaries. This results in better utilization of a rich environment. Animals in the estuarine environment are able to withstand large and rapid changes in salinity and temperature.

Marshes are dominated by emergent vegetation and the substrates are high in organic content and relatively low in minerals and trace elements. The quantity of micro invertebrates which thrive on this wealthy decaying marsh grass has not been estimated, nor has the actual production of small fishes which swarm into tidal marshes at high tide, or the crustaceans and mollusks. Many forms of oceanic life migrate into the estuaries and tidal marshes for important portions of their life histories. An estimate of the

primary productivity of various ecosystems is shown in Table II, which illustrates the enormous productivity of estuaries, tidal marshes and deltas.

Table II

General Orders of Magnitude of Gross Primary Productivity in Terms of Dry Weight of Organic Matter Fixed Annually

Ecosystem	$gm/m^2/year$	lbs./acre/year
Land Deserts, Deep Oceans	Tens	Hundreds
Grasslands, forests, eutrophic lakes, ordinary agriculture	Hundreds	Thousands
Estuaries, Deltas, Coral Reefs, Intensive Agriculture (Sugar cane, rice, etc.)	Thousands	Ten-thousands

J. Social, Economic and Land Use

1. Settlement and Population

Indian settlement occurred in Oregon some 15,000 years ago with emigration from Asia via the Aleutian Islands. Only relatively small populations were attained. The Indians did not domesticate animals (until the introduction of the horse) or develop agriculture. Subsistence depended on a hunting, fishing, gathering way of life. (Oregon State University-1968).

White settlement began in the 1780's and 1790's. The first white men in Oregon were the fur trappers of the Hudson Bay and Northwest Companies. In 1811 the Pacific Fur Company of John Jacob Astor founded the city of Astoria on the south side of the Columbia River. Farming settlement commenced in the fertile Willamette Valley in the 1830's, and the first sawmill was established in Oregon City in 1832.

The gold rush of 1849 diverted settlers to California rather than Oregon. However, the demands for farm produce and lumber in California proved a boon to Oregon farmers and sawmills.

Gold was discovered in Oregon in the Rogue River area in the 1850's, and in the John Day and Powder River areas in the 1860's. This provided an impetus to settlement, and marked the beginning of the eastern Oregon livestock industry. The Homestead Act of 1862 also encouraged an influx of settlement. This settlement took place fairly rapidly in the more fertile valleys of western Oregon - but was of a different character in eastern Oregon and the Montane Coniferous sub-biome. Here fertile soils,

favorable topography and available water were much more limited except for small sheltered valleys between ranges. Mining and timber harvesting were the main attraction for much of the early settlement.

The transcontinental railroad was completed in 1869, but trunk lines were not extended into Oregon until the 1880's. The few small scale "Indian Wars" in Oregon occurred in the period 1860-1880, and by 1883 most Indians were located on reservations. These factors contributed to an acceleration of settlement after 1880, which reached its peak around the period 1900-1910.

The 20th century has seen an accelerating trend to urbanization of Oregon's population. In 1900 two-thirds of the population lived on farms, while today nearly two-thirds reside in towns of over 2,500 population. Large communities are concentrated in the Willamette Valley - with the Portland metropolitan area containing over one-fourth of the total population. Deep water ports, low cost hydroelectric power, and availability of labor have contributed to intensive development of the area (Oregon State University-1968).

Population clusters or minor areas of concentration have developed along the coast, supported by small ports, fishing, and an increasing tourist trade.

Outside of these areas, communities tend to be small, and are oriented to logging, ranching or tourism.

The total state population increased 18.7% in the 1960-1970 decade. This increase was concentrated in urban areas, with most rural

areas showing a population decrease. The Bureau of Census projects a 15% increase for the period 1970-1980, compared to a national average projection of 11.7%. Nearly all this increase in projected for urban areas (Economic Profile for BLM in Oregon - 1972).

2. Land Use

a. General

The major land area of Oregon is devoted to forestry or livestock grazing use. Some 45% is classified as forest land, and 41% as grazing land. Only about 10% of the land is under cultivation. The following table shows the breakdown of major land uses.

Present Land Use in Oregon

(Oregon Department of Planning and Development-1964)

Use Category	Acres (1,000's)	Percent
Urban	294	0.49
Industrial	96	0.16
Military	64	0.10
Intensive Agriculture	4,011	6.52
Dryland Farming	2,051	3.33
Forests	27,572	44.84
Parks	192	0.32
Conservation	1,379	2.25
Grazing	25,686	41.50
Non-Productive	298	0.49

About 56% of Oregon land is in some form of public ownership - with the Federal government administering some 50.2% of the state land area. BLM is the largest landowner, administering slightly over 50% of the Federal land, or about 25% of the State's total. The U.S. Forest Service administers almost another 25%. State agencies administer approximately 3%, with the State Land Board and State Board of

Forestry being the principal agencies. (Economic Profile for BLM in Oregon-1972) Figure 20 shows major Federal land ownership.

No major changes are foreseen in land use in the near future. However, it is expected the next decade may see some 164,000 acres of farmland converted to urban, industrial, and transportation uses (Willamette Basin Comprehensive Study, 1969). Also, there has been an accelerating trend in "recreation" subdivision developments on some private forest land and Cold Desert sub-biome areas. State and local government land use controls of such developments are becoming increasingly stringent - and the future trend in these developments is hard to predict.

b. Commercial - Industrial

Throughout its history, the forest products industry has been the leading industry in Oregon. The wood products industry presently accounts for 46% of total manufacturing employment and 49% of manufacturing payrolls. There is a trend to greater diversification of Oregon's industrial mix. The following table shows the relative lessening of wood products in the State economy (extracted from "Oregon Economic Statistics" 1971 - Bureau of Business and Economic Research - University of Oregon).

Percentage of Employment by Industry

	1950	1960	1970
1. Lumber and wood products	18.3	14.1	9.4
2. Other manufacturing	8.7	10.1	11.5
3. Line 1 expressed as a percentage of total manufacturing employment	68	58	46

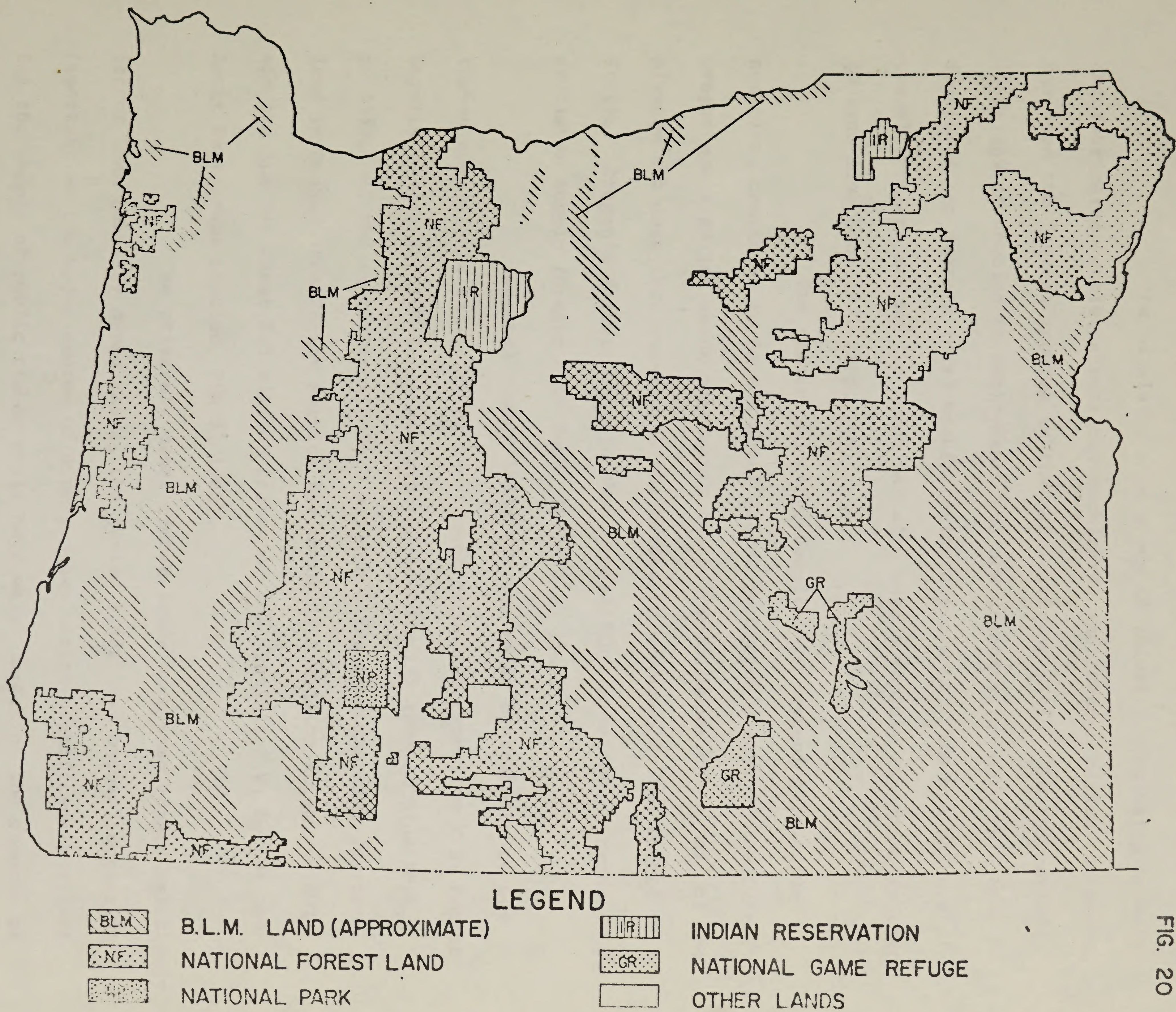

BLM
NF
IR
NP
GR
LEGEND
BLM B.L.M. LAND (APPROXIMATE)
NF NATIONAL FOREST LAND
NATIONAL PARK
IR INDIAN RESERVATION
GR NATIONAL GAME REFUGE
OTHER LANDS

FIG. 20

The metals-related group of industry, including primary and fabricated metals, electrical machinery, and transportation equipment has been the fastest growing in the manufacturing field. In the period 1959-1969 it doubled in employment, and now accounts for more than one-fourth of the State's total manufacturing employment. The manufacture of travel trailers and mobile homes has also been a rapidly expanding industry (Oregon Blue Book 1971-72 p. 144).

The timber industry, despite its lessening relative position, continues to be the chief factor in Oregon's economic activity. Oregon now supplies about one-fourth the softwood lumber, over half of the plywood and more than one-fourth the hardboard produced in the United States. Oregon's forests contain about one-fifth the nations current sawtimber supply (Oregon Blue Book, 1971-72 p. 154).

Federal timber lands are the major contributor to the timber supply. In 1971, 38% of the timber harvested came from U.S. Forest Service lands, and BLM lands contributed another 13% (Oregon Blue Book, p. 155). Of the approximately 26.6 million acres of commercial forest land in Oregon, the Forest Service has about 12.5 million acres, or 47%; and the BLM has about 2.5 million acres, or 10% (Pacific N.W. Forest and Range Experiment Station, PNW-9, 1965).

As privately owned timber lands have been logged relatively faster than publicly owned lands, the public lands have become increasingly important as the major source of supply. Any action significantly effecting the supply of public timber would have major impact on the economy of the State.

c. Agricultural

Agriculture, including range livestock, is the second largest contributor to the economy of Oregon. Agricultural production may be divided into six main categories. The production and value of these groups for 1969 is given in the following table. It can be seen that livestock accounts for 46% of total value.

Item	Production (Tons)	Value ($)
Grain, Forage, Misc.	5,021,000	161,767,000
Seed Crops	119,655	27,311,000
Tree fruits and nuts	353,200	44,619,000
Vegetables	745,790	48,578,000
Berries	65,880	14,730,000
Total Farm Marketings	6,305,525	307,005,000
Livestock	--	263,706,000
Total Marketings	--	570,711,000

(Oregon Blue Book 1971-72, p. 146)

The largest contiguous areas of cropland are located in the Willamette Valley, the Columbia Basin of northeastern Oregon, and the Snake River Basin of eastern Oregon. Sizeable acreages of highly productive cropland are also developed in the Deschutes - Jefferson County area of central Oregon, and the Klamath Basin on the Oregon-California border.

The leading individual crops in cash value are - hay, wheat, potatoes, pears, barley, snap beans, ryegrass seed, and strawberries. Several crops are of national significance. Oregon leads the nation in production of winter pears, sweet cherries, filberts, snap beans, several berry crops, and many grass seed crops. Twelve percent of the nations frozen food production and 5% of its canned food production comes from Oregon.

The largest segment of the livestock industry is that devoted to range livestock - principally beef production in eastern Oregon. Sheep numbers have steadily declined since 1940 in the Pacific Northwest. A scarcity of herders, problems with predatory animals, and competition with cattle has tended to force sheepmen from the areas east of the Cascades. While the range sheep industry is not likely to recover, there has been an increase in farm flocks in western Oregon. These flocks are not dependent on public lands to any significant degree.

Cattle production is concentrated in the eastern Oregon counties - which contain over 70% of the cattle numbers in the State. Federal lands are a significant factor in ranching operations - as most livestock make seasonal use of public lands. In 1964 the BLM and Forest Service provided about 13% of the annual forage requirement of eastern Oregon cattle. However, even more significant is the fact that during the four month period from June through September - when the majority of the use is permitted - these Federal lands provided 39% of the total requirement (Station Bulletin 604, Agricultural Exp. Sta., Oregon State University-1968). Any action having a significant impact on the seasonal availability of Federal range lands would also result in a significant impact on the local economy of most eastern Oregon counties.

d. Recreation

Oregon's recreation base provides one of its greatest natural assets. It provides for participation in all types of outdoor recreation for a varied and satisfying use of leisure time.

Water provides the greatest attraction for recreationists. The Pacific Ocean provides a coastline of sandy beaches, coves, and headlands. There are a wealth of lakes, ranging from small alpine ponds to large lakes and reservoirs. There are numerous snow fed mountain rivers and streams.

Anglers are attracted by the numerous and varied fishing opportunities available. The Rogue, Umpqua, Columbia, Willamette, and Deschutes are some of the noteworthy fishing streams. Anglers accounted for some 5,184,000 recreation days in 1970 (Oregon State Game Commission-1972).

An abundance of wildlife provides the base for a wide range of recreational activities - hunting, photography or just sightseeing. Species present range the gamut from big game to song birds. Hunters alone accounted for 3,100,000 recreation days in 1970 (O.S.G.C.-1971).

Rockhounding is an increasingly popular recreational activity - particularly in the Cold Desert and Montane areas, as are activities dependent on off road vehicle use.

The combination of topography and vegetation - coastal, lowland valley, mountain, and high desert plateau - provide a great variety of seasonal recreational opportunities within relatively short travel time from major urban areas.

Federal, State, local government and private enterprise have provided a variety of recreational developments. There are numerous developed campsites, picnic sites, roadside rest areas, ski areas, and developed trails. Many areas have been designated as wilderness, primitive,

or natural areas; and others are under study. Dams constructed by the Bureau of Reclamation and Corps of Engineers have created reservoirs providing a wide range of water based recreation opportunities. Federal lands include some of the most scenic land in the State, provide the greater share of the fishing and hunting opportunities, and have provided numerous developed sites - primarily to serve campers and picnickers. The BLM has 71 developed sites in Oregon, principally in the western Oregon districts.

Recreation and tourism constitute the third largest input to the Oregon economy. Visitors from out-of-state spend more than 326 million dollars in Oregon annually. Oregonians themselves spend as much as 200 million dollars on traveling within their State (Oregon Blue Book 1971-72, p. 165).

It is estimated there were more than 10 million recreation visits to BLM lands in Oregon in FY 1972. Most prevalent uses were sight-seeing, camping, picnicking, fishing and hunting (BLM Facts, Oregon and Washington 1971-72).

e. Minerals

Minerals and mining were a key factor in the initial settlement of many areas. While the importance of minerals to the Oregon economy has decreased since early settlement, it is still a significant resource value.

The mineral industry generally produces between 75 and 100 million dollars of raw materials annually. The following table shows production for the two most recent years:

MINERAL PRODUCTION IN OREGON

(Bureau of Mines-1972)

Item	Value (thousand dollars) 1971	1972
Clays	255	289
Copper	3	-
Diatomite	1	withheld
Gem Stores	755	793
Gold	10	-
Lime	1,989	1,690
Mercury	withheld	-
Nickel	"	withheld
Pumice & Cinder	1,239	1,522
Sand and Gravel	28,707	30,429
Silver	6	-
Stone	26,708	25,669
Items that cannot be described	18,212	19,413
Total	77,885	79,805

The mining and metallurgical industry provides jobs directly for 12,000 wage earners. Non-metals account for over 90% of the total value; with sand, gravel, and stone accounting for the major share of non-metals. Oregon leads all states in the production of gem stones.

In the field of metals, Oregon was the sole producer of primary nickel in the United States in 1972. Also, 1972 saw a resumption of gold mining activity at the Bald Mountain mine near Sumpter, and at Pine Creek northwest of Baker.

The State Department of Geology and Mineral Industry received a grant from the Bureau of Mines to conduct research on location of geothermal reserves within the State. Known geothermal reserves exist on BLM lands in the Lakeview and Vale Districts.

Present interest in BLM lands for minerals is primarily restricted to sand, gravel, rock, pumice and cinder. These are generally small operations with little impact on the total economy. They do have local significance in certain areas.

There has recently been a great revival of interest in oil and gas leasing of public lands, although past explorations have produced only negative results.

K. Aesthetics and Human Interest Values

1. Aesthetics

The great variety of topography and vegetation found in Oregon provides a wealth of scenic attractions - ranging from ocean coastline, through mountain and fertile valleys, to high desert plateau.

The Coniferous Forest provides some of the most spectacular scenery found in the state. The rainforests of the Douglas-fir region of western Oregon provide a more or less continuous panorama of towering forests, broken by picturesque streams tumbling from the mountain to the ocean. The ocean shoreline provides scenery which annually draws numerous sight-seers.

Important mountains include the Coast Range of western Oregon, the Cascades in Central Oregon, the Klamath-Siskiyou mountains in the southwest, and the Blue and Wallowa mountains in the northeastern portion of the state. Water based scenic attractions are many and varied. The Rogue River is a federally designated Wild and Scenic River, while the State System of Scenic Waterways includes the Rogue, Illinois, Minam and Deschutes, and also the John Day and Owyhee in other biomes. Others are under considerations.

The numerous lakes include Crater Lake, a nationally famous scenic attraction, and center of the only National Park located in Oregon.

Land forms of the Coniferous Forest vary from the rounded foothills of the Coast Range and Cascades to towering angular

peaks such as Mt. Hood and the Three Sisters; and from relatively flat basins to nearly vertical canyons. Natural lines occur as abrupt changes in vegetation types - caused by soil changes, amount of available moisture, or rock intrusions. The vastness of scale and extreme vertical relief are most impressive to sightseers. Colors are dominated by the green of the conifer cover, while the colors of exposed soil and rock become more apparent at the higher elevations.

The Cold Desert, with the interspersed juniper areas, provides a visual environment typified by flat dry lakebeds or low rolling hills occasionally broken by small mountain ranges or vertical fault scarps. Seldom is the observer out of sight of a mountain somewhere in the area of view. The Steens Mountains offer some of the most spectacular scenery found in eastern Oregon. Texture of the Cold Desert is generally the relatively soft one of vast expanses of sagebrush, broken by bare ridgelines, gullies, or dry lakebeds. Texture of the Juniper areas vary with density of the stand - from continuous dense canopy to an open random pattern.

Color is generally not an important factor in either the Cold Desert or Juniper. It is dominated by the gray-green of the vegetation, or the flat grays and browns of the soils typical for the area. Lines also play a minor role in the character of the area. Those that are evident are due to abrupt vegetation changes, or due to man's activities - such as roads, fences, or powerlines. These intrusions are relatively few, but are visible for many miles. Scale

is difficult to define, except for woodland areas, as the vastness of open space dominates the landscape.

The Palouse Grassland can be described as gently rolling hills and flatland expanses broken by streams. Major streams in the area include the John Day and Umatilla Rivers. The texture of the natural landscape is the soft texture of grassy slopes interrupted by rock outcrops. In those areas devoted to agriculture the texture changes from field to field. Color is not a dominant factor - tending to be a generally muted monotone, except for certain agricultural areas. Lines are also minor in the natural landscape, but become more obvious in agricultural areas - where field edges, crop rows, fence lines and roads may become a dominant visual element.

2. **Geological Values (Human Interest)**

The principal geological attractions of the Coniferous Forest are (1) the Pacific Ocean coastline - with its erosion features, rock islands, sand dunes and steep cliffs; and (2) mountains with their glacial and volcanic features including canyons, pinnacle peaks, cinder cones, lava flows, pumice beds and hot springs.

The Cold Desert and Juniper Woodland contain vast expanses that, to some, may impart a feeling of monotony - but paradoxically, also contain some of the most intriguing and spectacular geologic features. There are many examples of volcanic activity - such as extensive lava flows (e.g., the Owyhee and Diamond Craters) and cinder cones. Impressive fault scarps can be found, with

Abert Rim being the largest such scarp in North America. There are eroded plateaus and impressive canyons - such as the Owyhee and Snake. There are also localized sand dune areas and hot springs. Fossil Lake in northern Lake County is a significant attraction.

The Grassland, being primarily flatlands, are generally void of geologic features which attract human interest. There are some significant canyons - such as the John Day. The John Day Fossil beds are a noteworthy paleonthologic attraction.

3. **Archaeological Values**

The Northwest Coastal Forest was the home of the salmon fishing oriented northwest coastal cultures. Village sites were along the streams, consisting of either pit or surface houses. Occasional rock shelters and some camp sites are found away from the streams. The mountain forests themselves were not generally lived in by the native Americans. They lived along the major water courses and used the forests for hunting and gathering. People of the Cold Desert and Grassland made use of the Coniferous Forest that was within range of their seasonal traveling ability.

The inhabitants of the Cold Desert and Juniper Woodland subsisted on a hunting-gathering culture, with no agricultural pursuits. In this dry area there is a direct relationship between water sources and archeological sites. Hunting of waterfowl was common around the many pleistocene lakes in the region. Campsites, caves, and chipping areas occur throughout the area - most commonly found around ancient lakebeds, major stream courses, and spring sites.

Inhabitants of the Palouse Grassland also did not develop any agriculture, and depended on a hunting-gathering way of life. Settlement was along river valleys, and archeological sites are commonly the remains of pit houses, camp sites and burial grounds. Petroglyphs and pictographs are found in numerous locations throughout the Cold Desert, Juniper Woodland and Grassland sub-biomes.

4. **Historical Values**

The history of Oregon, like much of the western states, is relatively so recent that it is difficult to judge present historical values from a short term evaluation.

Early settlement of the Coniferous Forest was oriented around lumbering and mining -- with some maritime and fishing activities along the coast. Remnants of old logging camps, mining activity, military posts, and some preserved homes of early pioneers are examples of existing reminders of the region's early history.

The Cold Desert and Juniper Woodland of Oregon are among the least inhabited areas in the nation. History here revolved around mining endeavors and the ranching industry. Evidence of early mining activity and military posts exists, as do examples of homesteading failures.

The Palouse Grassland area was generally homesteaded and converted to agriculture in the middle and late 1800's, and historical relics are rather uncommon.

Some historic trail routes traversed Oregon and provide reminders of some of the more memorable events in Oregon history. The Lewis and Clark exploration trail is one of the most significant.

Also important are the Oregon Trail emigration route in northern Oregon, and the Applegate Trail in southwestern Oregon.

5. **Cultural, Ethnic and Religious Values**

Native Indian Americans now number only 13,510 in Oregon - less than one percent of the total population. The Warm Springs Reservation in north-central Oregon is the only Indian reservation remaining in Oregon. The Klamath Reservation was terminated in 1958, but there is a locally significant Indian population residing in the area north and east of Klamath Falls.

Oregon was settled by people from a wide variety of nationalities, and the present population is not dominated by any particular ethnic or religious groups. The white, native born majority is more dominant in Oregon than for the nation as a whole.

1970 Population
(U.S. Dept. of Commerce, 1972, p. 28 and 35)

		Negro		% of
	White	Number	Percent	Foreign Stock*
Oregon	2,032,079	26,308	1.3	14.1
U. S.	177,748,975	22,580,289	11.1	16.5

*Foreign born, or native born but having one or both foreign born parents.

There are, however, small ethnic-cultural groups of significance in localized areas. The Indian population has been discussed above. In southeastern Oregon there is a group of Basques, originally brought to this country as sheepherders from the Pyranee Mountains of Spain and Portugal. Similarly, Irish sheepherders

concentrated in the southern Lake County area in south-central Oregon. The present population there has a significant segment of Irish. In the Snake River Valley crop farming area of east central Oregon there is a locally significant population of Japanese. Farm workers of Mexican ancestry are also locally significant in the area - as well as in certain portions of the Willamette Valley.

REFERENCES CITED

1. Agricultural Experiment Station, Oregon State University, Station Bulletin 604 - 1968.

2. Anonymous "Freshwater Biology and Freshwater Pollution Ecology", Environmental Protection Agency, Pacific Northwest Region, Corvallis, Oregon. June, 1971.

3. Anonymous "Water Quality Studies", Environmental Protection Agency, Pacific Northwest Region, Corvallis, Oregon. March, 1971.

4. Anthony, H.E., Field Book of North American Mammals, G.P. Putnam's Sons, N.Y., 625 pp., 1928.

5. Bailey, V., The Mammals & Life Zones of Oregon, North America Fauna No. 55, USDA Biological Survey, Washington, D. C., 416 pp., 1936.

6. Bailey, Reeve M., et al., A List of Common and Scientific Names of Fishes from the United States and Canada (Third Edition) American Fisheries Society, Special Publication No. 6, Washington, D. C., 1970, 150 pp.

7. Bertrand, A.B., & Scott, M.A., Check List of the Birds of Oregon, O.S.U. Book Stores, Inc., Corvallis, 1971.

8. Bond, C.E., Endangered Plants and Animals of Oregon - I. Fishes, Special Report 205, Agricultural Experiment Station, Oregon State University, Corvallis, Oregon, January 1966.

9. Bond, Carl E., Keys to Oregon Freshwater Fishes, Technical Bulletin 58 (Revised), Agricultural Experiment Station, Oregon State University, Corvallis, Oregon, January 1973.

10. Bureau of Land Management (1972) Unpublished interim soil inventory reports of the Medford and Roseburg Districts. Roseburg and Medford, Oregon.

11. Cleaver, F.C., Fisheries Statistics of Oregon, Fish Commission of Oregon, Contribution No. 16, September 1951.

12. Columbia-North Pacific Region Comprehensive Framework Study, Pacific Northwest River Basins Commission, Vancouver, Washington, September, 1972.

13. Cook, Wayne C., Colorado State University, Interview by BLM, November 2, 1972.

14. Cowan, I.M., and Guiguet, C.J., The Mammals of British Columbia, A. Sutton, Victoria, B.C., 1965.

15. Darling, F. Fraser and Milton, John P., Future Environments of North America. 1966. The Natural History Press, Garden City, N.Y. 767 pp.

16. Decker, Fred W. 1961. The Weather of Oregon - second edition. Oregon State University Press, Corvallis, Oregon.

17. Driscoll, Richard S. 1964. Vegetation-soil Units in the Central Oregon Juniper Zone. U.S. Forest Service Research Paper PNW-19, 60 pp. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

18. Dyksterhuis, E.L., G.H. Simonson, J.A. Norgren, and R.E. Hasler 1969. Oregon's long range requirements for water. General soil map report with irrigable areas, John Day Drainage Basin. Appendix I-6. Oregon State University, Corvallis, Oregon.

19. Craig, Joseph A. and Robert L. Hacker, The History and Development of the Fisheries of the Columbia River, Bulletin No. 32, U.S. Department of the Interior, Bureau of Commercial Fisheries, U.S. Government Printing Office, Washington, D. C., 1940.

20. Environmental Protection Agency, Freshwater Biology and Pollution Ecology, Training Manual, June 1971.

21. Fenneman,N.M. Physiography of the Western United States, McGraw Hill Book Company, New York 1931, p. 432.

22. Fernald, H.T., & Shepard, H.H. Applied Entomalogy, McGraw-Hill, N.Y. 385 pp., 1955.

23. Fish Commission of Oregon, A Guide to Oregon's Rocky Intertidal Area, Education Bulletin No. 5, July 1970.

24. Fish Commission of Oregon, Commercial Food Fish Landings in Pounds Round Weight by State of Oregon Administrative District for Calendar Year 1970, Mimeographed Statistics, May 1971.

25. Franklin, Jerry F. and Dyrness, C.T. 1969. Vegetation of Oregon and Washington. U.S. Forest Service Research Paper PNW-80, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

26. Franklin, Jerry F., Dyrness, C.T. 1973 (personal communication).

27. Gabrielson, I.N., & Jewett, S.G., Birds of the Pacific Northwest, With Special Reference to Oregon, Dover Publications, N.Y. 650 pp., 1940.

28. Gratowski, H. 1961. Brush Problems in Southwestern Oregon. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, January 1961.

29. Gharrett, John T. and John I. Hodges, Salmon Fisheries of the Coastal Rivers South of the Columbia River, Fish Commission of Oregon, Contribution No. 13, December 1950.

30. Hubbs, Carl and Robert R. Miller, Diagnoses of New Cyprinid Fishes of Isolated Waters in the Great Basin of Western North America, Transactions of the San Diego Society of Natural History, Vol. 17, No. 8, September 1972.

31. Hunt, Charles B., Physiography of the United States, W. H. Freeman and Company, San Francisco, 1967 p. 357.

32. Klots, A.B. & E.B., Insects of North America, Doubleday & Co., Inc., N.Y., 250 pp., 1970.

33. Kormondy, Edward J. 1969. Concepts of Ecology. Prentice-Hall, Inc. Englewood Cliffs, N.J. 209 pp., illus.

34. Lindsay, M.G. and G.H. Simonson 1969. Oregon's long-range requirements for water. General soil map report with irrigable areas, Powder Drainage Basin. Appendix I-9, Oregon State University, Corvallis, Oregon.

35. Lindsay, M.G., B.B. Lovell, J.A. Norgren, G.H. Simonson, B.R. Thomas and D.W. Anderson 1969. Oregon's long-range requirements for water. General soil map report with irrigable areas, Malheur Lake Drainage Basin. Appendix I-12. Oregon State University, Corvallis, Oregon.

36. Lowell, B.B., M.G. Lindsay, J.A. Norgren, D.A. Anderson, and G.H. Simonson 1969 (a). Oregon's long-range requirements for water. General soil map report with irrigable areas, Malheur River Drainage Basin. Appendix I-10, Oregon State University, Corvallis, Oregon.

37. Marriage, Lowell D., The Bay Clams of Oregon - Their Economic Importance, Relative Abundance, and General Distribution, Fish Commission of Oregon, Contribution No. 20, May 1954.

38. Marshall, D.B., Endangered Plants & Animals of Oregon (III Birds) Oregon State University, 1969.

39. Miller, George C. and Jack M. VanHyning, The Commercial Fishery for Fresh-Water Crawfish, Pacifastacus leniusculus (astacidae), in Oregon, 1893-1956, Research Reports, Fish Commission of Oregon Vol. 2, No. 1, 77-89, December 1970.

40. Miller, Robert R., Threatened Freshwater Fishes of the United States Transactions of the American Fisheries Society, Vol. 101, No. 2, April 1972.

41. Minore, Don 1972, Classification of Forest Environments in the South Umpqua Basin. U.S.F.S. PNW Experiment Station, Portland, Oregon.

42. Newton, V.C. Jr. Subsurface Geology of the Lower Columbia and Willamette Basins, Oregon, Oil and Gas Investigations No. 2, Oregon State Department of Geology and Mineral Industries, Portland, Oregon 1969 121 p.

43. Newton, V.C. and Corcoran, R.E. Petroleum Geology of the Western Snake River Basin, Oil and Gas Investigations, No. 1, ODGMI, Portland, Oregon, 1963, 65 p.

44. Norgren, J.A., G.H. Simonson, B.R. Thomas, M.G. Lindsay, B.B. Lovell, and D.W. Anderson 1969. Oregon's long-range requirements for water. General soil map report with irrigable areas, Deschutes Drainage Basin. Appendix I-S. Oregon State University, Corvallis, Oregon.

45. Norgren, J.A., and G.H. Simonson, 1969. Oregon's long-range requirements for water. General soil map report with irrigable areas, Umatilla Drainage Basin. Appendix I-7. Oregon State University, Corvallis, Oregon.

46. Odum, E.P., Fundamentals of Ecology, W. B. Saunders Co., Philadelphia, 2nd edition, 546 pp., 1959.

47. Olterman & Verts, Endangered Plants & Animals of Oregon (IV Mammals), Oregon State University, 1972.

48. Oregon State Game Commission - 1, Annual Reports - Fishery Division, 1964-70, Inclusive.

49. Oregon State Game Commission, A Checklist of Oregon Mammals,Amphibians and Reptiles, 1972.

50. Oregon State Game Commission - 2, Basin Investigations: Upper Willamette, June 1966; Powder, August 1967; Malheur, September 1967; North Coast, April 1968 and Supplement, January 1972; Owyhee, April 1969; Klamath, April 1970; Rogue River Basin, November 1970 and Supplement, April 1972; Goose and Summer Lakes, November 1971; Umpqua, February 1972; South Coast, April 1972; and unpublished reports on John Day and Deschutes.

51. Oregon State Game Commission - 3, Rock, Surf and Bay Fishes of Oregon, Information Leaflet No. 14.

52. Odum, Eugene P. 1959. Fundamentals of Ecology. W. B. Saunders Co. Philadelphia, Pa. 546 pp., illus.

53. Oregon Blue Book, 1971-1972.

54. Oregon Department of Geology and Mineral Industries, "Physiographic Map of Oregon with Geomorphic Divisions".

55. Oregon Department of Planning and Development, Resources for Development - 1964.

56. Oregon State Game Commission - 4, Oregon Game Code, 1971-1972.

57. Oregon State Game Commission, Bulletin, 12 pp., January 1973.

58. Oregon State Game Commission, Fish Harvest Recreation Days and Fishery Values for 1970, Unpublished data-1972.

59. Oregon State Game Commission, Annual Report - 1971.

60. Oregon State University Press, Atlas of the Pacific Northwest-1968.

61. Pacific Northwest Forest and Range Experiment Station, PNW-9, 1965.

62. Pacific Northwest River Basins Commission, Willamette Basin Comprehensive Study - Appendix A, Study Area, 1969.

63. Pacific Northwest River Basins Commission, 1969. Columbia-North Pacific Region, Comprehensive Framework Study, Appendix II, - The Region. Vancouver, Washington, June 1969.

64. Pacific Northwest River Basins Commission, Willamette Basin, Comprehensive Study of Water and Related Land Resources, Appendix D, Fish and Wildlife, 1969.

65. Pacific Northwest River Basins Commission, Comprehensive Framework Study of Water and Related Lands, Columbia-North Pacific Region, Appendix XIV - Fish and Wildlife, November 1971.

66. Peck, Morton E., A Manual of Higher Plants of Oregon, Binfords and Mort, Oregon State University Press and National Science Foundation, 1961.

67. Peterson, R.T., A Field Guide to Western Birds, Houghton Mifflin Co., Cambridge, 240 pp., 1941.

68. Power, W.E. and G.H. Simonson 1969. Oregon's long-range requirements for water. General soil map report with irrigable areas, Rogue Drainage Basin. Appendix I-15. Oregon State University, Corvallis, Oregon.

69. Shay, Ron, Oregon's Rare or Endangered Wildlife, Oregon State Game Commission, Game Bulletin, January 1973.

70. Shelford, V.E., The Ecology of North America, University of Illinois Press, Urbana 1963, pg. 3.

71. Spurr, Stephen H. 1964. Forest Ecology. The Ronald Press Co. New York, N.Y. 352 pp., illus.

72. Stebbins, R.C., A Field Guide to Western Reptiles & Amphibians, Houghton Mifflin Co., 1966.

73. Sternes, Gilbert L. 1966. Climatological Data for Oregon's Columbia Basin Counties. Special Report 225, Cooperative Extension Service, Oregon State University, November 1966, p. 1.

74. Sternes, Gilbert, L. 1967. Climates of the States - Oregon. Climatography of the United States No. 60-35, U.S. Department of Commerce, Environmental Sciences Services Administration, Environmental Data Service, Washington, D. C., August 1967.

75. Steward, Albert N., Dennis, LaRea J., and Helen M. Gilkey, Aquatic Plants of the Pacific Northwest, Studies in Botany Number 11, Oregon State College, Corvallis, Oregon 1960.

76. Stoddart, Laurence A. and Smith, Arthur D. 1955. Range Management. McGraw-Hill Book Co., Inc. New York, N.Y., 433 pp., illus.

77. Storm, R.M., Endangered Plants & Animals of Oregon (II Amphibians & Reptiles), Oregon State University, 1966.

78. Swanson, D.A. Reconnaissance Geologic Map of the East Half of the Bend Quadrangle, Crrok, Wheeler, Jefferson, Wasco, and Deschutes Counties, Oregon USGS Miscellaneous Geologic Investigations Map I-568, 1969.

79. Thomas, B.R. J.A. Pomerening, and G.H. Simonson, 1969. Reconnaissance soil survey of the Willamette Basin, Oregon. Segment III: Uplands outside National Forests. Special Report 269. Agricultural Experiment Station. Oregon State University, Corvallis, Oregon.

80. U.S. Army Corps of Engineers, Annual Fish Passage Report for 1969, North Pacific Division, Portland and Walla Walla district.

81. University of Oregon, Bureau of Business and Economic Research, Oregon Economic Statistics, 1971.

82. U.S. Bureau of Census. County and City Data Books 1950-1960.

83. U. S. Bureau of Sport Fisheries and Wildlife, Rare and Endangered Fish and Wildlife of the United States, 1968 edition.

84. U.S. Department of Agriculture 1964. Soil Survey, Tillamook Area, Oregon, Superintendent of Documents, U.S. Govt. Printing Office, Washington, D. C.

85. U.S. Department of Agriculture 1970. Soil Survey, Curry Area, Oregon. Superintendent of Documents, U.S. Govt. Printing Office, Washington, D. C.

86. U.S. Department of Agriculture, Forest Service Research Paper, PNW-80, Portland, Oregon.

87. U.S. Department of the Interior, Natural Resources, Ecological Aspects, Uses and Guidelines for the Management of Coos Bay, Oregon, June 1971.

88. U.S. Fish and Wildlife Service, Preliminary Survey of Fish and Wildlife in Relation to the Ecological and Biological Aspects of Yaquina Bay, Oregon, United States Department of the Interior, Portland, Oregon, November 1968.

89. U.S. Department of Interior, Fish and Wildlife Service, Rare and Endangered Fish and Wildlife of the United States, Resource Pub. 34. Superintendent of Documents, Washington, D. C. 200 pp., 1968.

90. U.S. Department of Interior, Conservation of Endangered Species and Other Fish or Wildlife, Federal Register, Vol. 35, No. 199, 1970.

91. U.S. Department of Interior, Bureau of Land Management, Preliminary Draft, Upland Oil and Gas Leasing Programmatic Environmental Impact Statement, 1972.

92. U. S. Department of Interior, Bureau of Land Management, Oregon State Office, BLM Facts, Oregon and Washington - 1971-72.

93. U. S. Department of Interior, Bureau of Land Management, Oregon State Office, Economic Profile for BLM in Oregon - 1972.

94. U.S. Department of Interior, Bureau of Land Management, 1972. Preliminary Draft - Timber Management - A Programmatic Environmental Impact Statement. Washington, D. C.

95. U. S. Bureau of Mines, U.S.D.I. Mineral Industry Survey - 1972.

96. Vance, H.M., M.G. Lindsay, G.H. Simonson, 1969. Oregon's long-range requirements for water. General soils map report with irrigable areas. Grande Ronde Drainage Basin. Appendis I-8 Oregon State University, Corvallis, Oregon.

97. ________________ 1969(b) Oregon's long-range requirements for water. General soil map report with irrigable areas, Owyhee Drainage Basin. Appendix I-11, Oregon State University, Corvallis, Oregon.

98. Van Dersal, William R. 1938. Native Woody Plants of the United States. U.S. Government Printing Office, Washington, D. C.

99. Waldron, Kenneth D., A Survey of Bull Kelp Resources of the Oregon Coast, Fish Commission of Oregon, Research Briefs, Vol. 6, No. 2, 15-20, 1955.

100. Waring, R.H. 1969, Forest Plants of the Eastern Siskiyous: Their Environmental & Vegetational Distribution. School of Forestry, Oregon State University, Corvallis, Oregon.

101. Weaver, John E, and Clements, Frederick E. 1938. Plant Ecology. McGraw-Hill Book Co., Inc. New York, N.Y. 601 pp., illus.

102. Wells, Edward L. 1941, Supplementary Climatic Notes for Oregon, in Climate and Man, - Yearbook of Agriculture. U.S. Government Printing Office, Washington, D. C. p. 1085.

103. Wick, William Q., Crisis in Oregon Estuaries, Oregon State University Advisory Program.

104. Wilde, S.A., 1958. Forest soils. The Ronald Press Co. New York, 537 pp.

105. Zon, Raphael, 1941. Climate and the Nations Forests, in Climate and Man - Yearbook of Agriculture. U.S. Government Printing Office, Washington, D. C.

IV. <u>Environmental Impacts of Oil and Gas Leasing</u>

This section explores potential impacts that might occur with the oil and gas leasing actions described in Section II B. Although many of the impacts discussed in this section would never be allowed to occur under current Bureau standards, they are herein presented as if no standards of operation or performance existed.

Where differences in the nature or magnitude of impacts arise between the four phases of operations (i.e., exploration, development, production and abandonment), impacts are discussed by phase of operation beginning with exploration. To assist the reader in relating impacts to particular phases, underlining is used to identify the phase of operation under discussion. Where variations in impacts occur between sub-biomes, they are discussed separately following the general discussion of impacts common to all sub-biomes.

The first part, Ecological Interrelationships, provides a brief summation of the collective effects of impacts on the ecosystem, while the following parts describe the potential impacts on each separate component of the ecosystem.

A. Ecological Interrelationships

Unmitigated environmental impacts of the various discrete operations associated with oil and gas leasing are discussed individually in subsequent parts of this section. This part will deal collectively with the overall impact of the program on the total environment and its biota, thereby avoiding unnecessary repetition.

1. Man and the Biosphere

With man's development of modern industrial technology and its widespread application, the evolution of earthly life appears to have reached a turning point. In the past, all forms of life were subject to automatic natural controls. No species could succeed or multiply beyond a certain limit without encountering controls that would eventually restore it to its proper place in the biota, or eliminate it. Today these natural limitations are no longer fully effective. Man's intellect has enabled him to escape the controls of nature to a degree. He has achieved almost unlimited power to multiply his numbers and concurrently to destroy the natural resources which support him (Storer, 1953, p. 125).

2. Impacts on Ecosystems

At the level of the sub-biome (or ecosystem), the impact of a single activity can be realistically considered only in the context of its contribution to the cumulative effect of all of man's activities on the ecosystem (See again Section I E for additional discussion of the cumulative effect of multiple activities on an ecosystem).

In general, oil and gas operations which alter any of the abiotic or biotic components of an ecosystem have potential for adversely

affecting ecological interrelationships. Effects of oil and gas activities on individual components of the ecosystem are described in detail in the parts of this section which follow. The nature of many of the chain-like relationships in the cycles and flows that link the various environmental components are not fully known. However, it can be assumed that impacts on one part of the ecosystem will somehow affect the whole (BLM Preliminary Draft Environmental Impact Statement - Timber Management, 1972).

Removal of vegetative cover incidental to construction of seismic trails, access roads and drilling sites creates an immediate visual impact. The harassment of wildlife populations by man's activities has an obvious adverse effect. However, impacts on three primary environmental components - <u>soil</u>, <u>water</u> and <u>atmosphere</u> - are critical, because the condition of these three affects the welfare of the entire biotic community, directly or indirectly (Odum, 1959, p. 128). Any action associated with oil and gas operations which affects soil, water or atmosphere significantly, can upset the natural ecological balance. The immediate impacts of some actions may not be noticeable; e.g., the destruction of soil micro-organisms, the failure of water to infiltrate compacted soils in amounts adequate to maintain the nutrient cycle, etc. However, the resulting effects will become apparent, with passage of time, in the lack of vigor of the plant community or in higher mortality of vegetation, in greater volume of surface runoff and in increased stream turbidity, etc.

a. <u>Soil</u>

Soil is the major habitat of the decomposers (Ibid, p. 373). It also contains the basic elements and nutrients essential to the

functioning of the terrestrial producers; it is the medium in which nutrient cycling begins (See Section III B 2). Although the green plants can produce carbohydrates from water and the carbon dioxide of the atmosphere, synthesis of the more complex organic compounds requires varying amounts of mineral components which are found only in the soil (Kormondy, 1969, p. 35). Without these minerals, the vital processes of the producers cannot be completed. The continuing life of all organisms depends on the availability of these minerals. The soil is also the matrix in which root systems both anchor the plant community and serve as conductors for the movement of moisture and nutrients.

If the soil is polluted by saline water, spilled petroleum or other chemicals, there may be a complete cessation, or significant reduction, in the activity of the decomposer organisms because of the elimination or decrease of their populations. If soil is compacted by heavy equipment, off-road traffic, etc., its pore space may be so reduced that its permeability and water-holding capacity will be impaired (Spurr, 1964, pp. 100, 101, 116, 117). Both soil pollution and soil compaction then, may inhibit nutrient cycling and reduce the vigor of the dependent community of green plant producers.

Massive soil movements which expose underlying rock substrates eliminate the possibility of restoring the original plant communities in any period short of geologic time. Landslides may occur as a result of poorly conceived operations where excavation is done on steep terrain.

b. Water

The aquatic ecosystem's stability depends on the maintenance of water quality. Sedimentation and pollution of natural waters resulting from certain oil and gas operations can kill aquatic micro-organisms, vertebrates and aquatic vegetation, or inhibit the capacity of the aquatic biota to reproduce and maintain itself. These effects could be particularly insidious in combination with slow but cumulative forms of pollution by other agents; e.g., by pesticides and radioactive contaminants (Darling and Milton, 1966, p. 510). Certain animals, at the culmination of short food chains, may be eliminated first, even when general concentrations of pollutants are very low. Eventually, the habitat may be sterilized (Ibid.).

Terrestrial birds and mammals partially dependent upon natural waters, as well as aquatic and amphibian life forms, may also be adversely affected by degradation of water quality. The direct impact on the quality of water for human use may be very significant.

c. Atmosphere

Emissions of toxic gases during any phase of oil and gas operations can cause thorough, if relatively local, destruction of vegetation (Ibid.). While industry-related increases in atmospheric carbon dioxide have had no demonstrable effect on organisms, concentrations of air-borne substances ("smog") have been shown to inhibit photosynthesis and plant growth (Odum, 1959, pp. 124, 451). Under certain weather conditions, petroleum refining operations may be a major contributior to urban smog (Darling and Milton, 1966, p. 101). The adverse effect of atmospheric pollution on human and animal health can be significant.

Thus, impacts on soil, water, and atmosphere may destroy decomposers, break the nutrient cycle, make it impossible for producers to function, and so alter the habitat that consumers survive with difficulty, or fail to survive. In more concrete terms, this means that a plant community may be lost and with it the food supply and protective cover which supports the existence of a resident wildlife population, with corollary modification of micro-climate which will delay the restoration of vegetative cover. It means that a stream may no longer be capable of sustaining aquatic life, and that a race of anadromous fish may disappear. It means that the health of a human population, and perhaps its continuing existence, may be threatened by degradation of air and water quality. Environmental impacts affect ecological interrelationships in ways which are too interwoven and intricate for complete description.

Ecosystems are partially interdependent. Alteration or environmental degradation of one ecosystem may have offsite impacts on the ecological interrelationships of another. Air movement can carry atmospheric pollution from one ecosystem to another. Water pollution originating in one ecosystem can degrade water quality in another by downstream movement through a natural drainage common to both. Harassment by man, or loss of food supply and cover, may cause a motile animal species to emigrate from one habitat to another where it may compete with resident species.

The natural balance is most readily disturbed in fragile ecosystems. The impact of man's disruptive activities is of greatest magnitude in fragile plant communities, where productivity is low.

Ecological interrelationships are most stable in ecosystems of high productivity; these communities are usually capable of recovering rapidly from man-caused disturbance (Darling and Milton, 1966, p. 53). Rich forests are high on the scale of stability among plant communities; deserts rank lowest (Kormondy, 1969, p. 153).

3. Ecosystem Stability by Sub-biome

a. Northwest Coastal Coniferous Forest

The highly productive Coastal Forest has the most inherently stable ecological interrelationships. Its natural balance is less apt to be upset by the impact of man's activities than that of any of the other sub-biomes. Yet, as with all ecosystems wherein a large portion of nutrients is held within the sub-biome, there is danger that exploitation may reduce future productivity; i.e., that periodic removal of timber by harvesting may eventually deplete nutrients and impair their cycling (Odum, 1959, p. 393).

The streams of the Coastal Forest, and the adjoining coastal estuaries, are important producers of anadromous and resident fish and shellfish. Some of these valuable aquatic ecosystems have already been severely damaged by discharges of industrial and domestic wastes, and by the onsite and offsite impacts of poorly planned and executed road construction and logging operations. Additional impacts of oil and gas operations could produce cumulative effects which would destroy the productivity of these waters.

b. Montane Coniferous Forest

In the Montane Forest, the natural balance is most stable in the more productive zones at intermediate elevations. Ecological interrelationships are most delicate in the higher elevational zones of alpine and subalpine vegetation, and in the fringe areas where this sub-biome adjoins the Juniper and Cold Desert sub-biomes. For many years much of the Montane Forest has served as summer range for domestic livestock (Stoddart and Smith, 1955, pp. 76,77; 84-87). The natural balance of some plant communities has been impaired by overgrazing and by road construction, logging and mining. Oil and gas operations in such areas could contribute significantly to total cumulative effects on ecological interrelationships.

The Montane Forest is the source of streams which contribute substantially to the Columbia River system's production of anadromous fish; e.g., the Deschutes, John Day and Grande Ronde Rivers. The upper reaches and some headwaters of these streams, within the Montane Forest, are important but fragile spawning areas which have already been degraded by man's activities. The impact of oil and gas operations on the natural balance of such ecosystems could be critical.

c. Broad Sclerophyll

The Broad Sclerophyll has long been associated with the frequent occurrence of wildfire. Consequently, much of this ecosystem has experienced repeated upsets of the natural balance. However, recovery seems to be rapid; chaparral species sprout readily from the roots after

the tops are burned (Weaver and Clements, 1938, pp. 531-533), and new growth quickly restores the original micro-climate.

Most of this sub-biome lies within the Rogue and Umpqua River drainages, both of which have valuable anadromous fisheries dependent on the maintenance of stable ecological relationships.

d. Palouse Prairie Grassland

Man's activities have modified the natural balance of most of the Palouse Prairie. Overgrazing and cultivation have replaced most of the original grassland community with sagebrush, annuals, and agricultural crops (Stoddart and Smith, 1955, p. 58; Weaver and Clements, 1938, p. 258). These alterations have probably caused significant changes of the biota associated with the original vegetation. Erosion of disturbed areas by wind and water has caused substantial loss of rich topsoil. The deep organic soil layer and rapid nutrient cycling have enabled this ecosystem to remain productive and to recover rapidly from man-caused disturbances. Yet, there is certainly a limit to the abuse that this ecosystem can endure. If that limit is exceeded, the natural balance may be permanently upset and the ecosystem's productivity destroyed (Odum, 1959, pp. 25-27). Oil and gas operations could add more stresses to those already testing the ecological stability of the grassland.

e. Juniper and Cold Desert

The Juniper and Cold Desert sub-biomes are characterized by slow nutrient cycling and low productivity. These are the most fragile of the Oregon sub-biomes; their plant communities recover very slowly

from any substantial disturbance. Both ecosystems have been damaged by overgrazing (Stoddart and Smith, 1955, pp. 63, 64; 75, 76), with consequent impairment of delicately-balanced ecological interrelationships. Oil and gas operations, if not carefully conducted, could increase the present imbalance significantly.

B. Physiography, Geology & Minerals

1. General

Environmental impacts of oil and gas leasing on physiography, geology and minerals occur primarily during exploration and development phases, and are essentially the same for all the sub-biomes. Such impacts may be greater, however, in those sub-biomes where there are higher concentrations of people; i.e., the Northwest Coastal and Montane Coniferous Forest.

2. Geological Subsidence

Geological subsidence is an impact which can occur under certain conditions during the production phase of the operation. In a closed reservoir, where the fluid holding rock is poorly consolidated, the removal of fluids and gases will leave void spaces unfilled, resulting in the compaction of the rock (from the weight of the overburden). The surface expression of this compaction is called subsidence. The amount of subsidence at the surface is equal to the amount of compaction of the compressed layer. Within oil fields, the depletion on producing zones 2 to 4 thousand feet deep or more may cause compaction to occur in the sands, depending on their physical character and mineral content (Cook, T. D., 1972, p. 69). This phenomenon was first observed in Texas in the early 20's at the edge of Galveston Bay. Several square miles subsided 3 or more feet with cracks appearing in the ground within the Goose Creek oil field. During the 1940's and 1950's the Wilmington oil field at Long Beach, then the third largest in the United States, sank some 26 feet over a 22 square mile area. This subsidence ruined buildings, cracked city pavements,

twisted railroad tracks, wrecked bridges, and sheared off oil wells resulting in approximately $100,000,000 worth of damage. (Marsden and Davis, 1967, p. 93.)

In areas where natural gas is dissolved in subsurface groundwater the withdrawal of the water has caused significant subsidence. The solubility of natural gas in salt water is low; therefore, large volumes of water must be pumped to obtain a large quantity of gas. Accumulating evidence indicates that under total stresses applied to unconsolidated heterogeneous deposits in overdrawn groundwater basins, most of the compaction is in the fine grained impermeable zones adjacent to the acquifer zone.

U.S.G.S. studies have shown through sensitive measurements that subsidence begins within a few minutes after the first withdrawal of subsurface fluids.

3. Increased Seismicity

The potential for earthquakes appears not to be much of a hazard in Oregon in terms of past seismic activity. The greatest potential occurs in the northern part of the Cascade Mountains section within the Coniferous Forest. The Portland area has the highest earthquake potential possibly related to the Portland hills fault zone which runs through the city.

A general outline of fault zones and earthquake epicenters is available in the 1970 National Atlas, pages 66-72. For detailed data on specific areas, the reader is referred to:

The Department of the Interior
United States Geological Survey
National Center for Earthquake Research
Jerry P. Eaton, Director
345 Middlefield Road
Menlo Park, California 94025

and

The Department of Commerce
National Oceanic and Atmospheric Administration
National Earthquake Information Center
Jim Lander, Director
1135 Broadway
Boulder, Colorado 80302

There are instances where earthquakes may be triggered or caused by drilling when fluids under pressure penetrate or lubricate shaley formations that are under tectonic stress or strain. It has been theorized that the liquid wastes injected into a shaley zone in a well at the Rocky Flats Arsenal near Denver, Colorado, triggered the earthquake that followed. The earthquakes ceased when the waste disposal was stopped.

"According to Hubbert and Rubey (1959), increase in pore pressure results in a decrease in shear strength of the rock, which could in turn release tectonic strain," (Earthquakes Related to Reservoir Filling, p. 18, 1972).

Blow-outs may conceivably cause earthquakes by injecting fluids under high pressure into formations under tectonic stress; however, there is little historic data to substantiate such events. Subsidence can also result from naturally occurring earthquakes causing settlement in unconsolidated sedimentary rocks or offsetting zones of weakness in surface rocks.

In conclusion, there is little historic evidence to indicate that injection or withdrawal of fluids during drilling and producing operations cause earthquakes. Several cases of subsidence, however, are known to have been caused by withdrawal of oil and gas. Drainage to surrounding structures resulted but, generally, the effects were limited to the central producing area.

4. Minerals

Well facilities, storage tanks, separation plants, pipelines and operation buildings may preclude mineral development in these areas during the productive life of the field.

C. Soils

1. General

In all sub-biomes, soil erosion and compaction result from any action which removes the vegetal cover and/or applies pressure to the soil. The loss of vegetal cover exposes soil to the erosive energies of rain and wind. Compaction impedes water infiltration, permeability, gas exchange and root growth (Lull, 1959; Steinbrenner, 1955). Consequently, water is more apt to flow overland causing rill and gully erosion. Natural productivity of the site is lessened due to the restricted root growth. This in turn causes a loss in vegetal cover which also exposes more of the area to the erosive forces of water and wind.

Roads, trails and other disturbed sites contribute substantially to soil erosion (Fredriksen, 1970). Removal of vegetation in conjunction with compaction also creates optimum conditions for soil erosion. Road and trail construction usually involves the removal of topsoil. If "cast aside," this life sustaining material is often the source of sediment. Site preparation for buildings, structures, etc. has the same adverse impact on soils as road construction. Trails are often the forerunners of gullies due to compaction and concentrated surface flow of water.

Chemical spillage or dumpage upon the soil can cause soil sterility or reduced plant growth. The time for recovery depends upon the nature and quantity of the substance spilled.

Landslides of various sizes may occur in all biomes. These landslides may be triggered by any activity which disturbs the natural

balances or concentrates water. Four factors involved in landslides are the nature of the geologic material, slope gradient, ground water, and soils. Burroughs, Chalfant and Townsend (1973) list the causative interactions, indicators and preventative measures for landslides in western Oregon.

The headwalls of drainages are usually steepened by natural erosion processes. These areas are very prone to mass soil wasting if they are disturbed. The headwall is that portion of a stram draw which has a very sharp increase in slope gradient from the toe of the mountain to the ridge top or saddle.

2. Impacts Related to Development Phases

Clearing of vegetation and soil disturbance caused by construction of access roads for both surface and subsurface intensive exploration activities will make soils more susceptible to erosion. Further erosion is caused by subsurface waters escaping from uncapped seismic shot holes.

Drill cuttings jetted with water from the mud pits during the construction of stratigraphic and wildcat well sites cause erosion. The chemical additives in the drilling mud, some of which are expelled with the drill cuttings, destroy nearby vegetation, in turn increasing the potential for erosion. The loss of drilling fluids or subsurface briney water through an aquifer which has been penetrated while drilling, can leak to the surface where the aquifer outcrops, destroying vegetation and causing erosion to take place. Well testing in which oil, gas or

brackish water are sprayed over the mud pits and nearby areas destroys vegetation and creates subsequent erosion channels. Accidents such as explosions, fires, spills, and leaks, as well as blowouts, in some cases, reduce vegetative cover over relatively wide areas (Broctett, Thue & Brown, 1971). These accidents can also cause soil sterility.

The overall erosional impact is greater and of longer duration during the development stage. However, it occurs over a limited area. Each well site is connected by roads which produces a criss-cross multiple road system and has a much greater impact than a single road. Each additional well increases the overall impact due to the additional area involved.

The impact on the soils at each successive well site due to jetting the drill cuttings, loss of drilling or subsurface fluids through near surface aquifiers, and well testing are the same as during exploration; however, the magnitude is reduced. Drilling muds are better controlled for each well and fewer drill stem tests are required. The construction of dams, tank batteries, pump stations, camps, and flow lines all have a moderate to severe impact on soils due to erosion caused by the loss of vegetation, compaction, and disturbance caused by construction. Construction of pipelines connecting field holding tanks to cross country arterial lines can cause severe erosion. The impact from accidents is the same as described in exploration. Each new well will increase the potential for accidents. The potential for well blowouts decreases if the subsurface pressures are known.

Erosional impacts of drilling will increase as the production phase is entered if additional oil and gas zones are discovered. Production facilities always compact and disturb the soil surface. Vegetative growth

is restricted because these facilities are used continuously. Secondary recovery operations have a moderate to severe impact on the soils due to erosion caused by construction of drill sites, flow lines from the separation facilities, and other water sources for injection wells. Continual use of roads and trails by heavy tank trucks and maintenance vehicles will cause extreme compaction of the soil surfaces. Wind erosion and overload water flow will be serious unless the roads are sufraced. Erosion also takes place along stream banks of streams are forded at low water crossings.

Surface disposal of drilling mud and solid wastes will cause a slight to severe impact on soils. This depends on the volume and content of such releases. Disposal of liquid wastes on the surface will cause a severe impact due to erisional channels being formed and the destruction of vegetative cover which takes place when brines or oily liquids enter the nutrient cycle.

The magnitude of fires, leaks, and spills during the production phase can be significantly greater than other stages of development. Fires at a tank battery or treatment plant can cause a serious impact on the soils due to both erosion due to loss of vegetative cover over large areas and by soil sterilization when baked under the extreme heat. Soils covered by facilities such as surfaced roads, buildings, etc. will be severely impacted. Oil leaks occuring in field gathering lines can cause soil sterility at the site of the leak.

Disturbed areas continue to cause erosional problems as the compacted or de-vegetated surfaces in many areas will not revegetate naturally upon

abandonment. Open shot holes may cause delayed surface slumpage with resultant erosion channels being formed when waters are allowed to escape. Breached mud pits and unplugged wells can also cause further erosional problems as escaping fluids damage or destroy the vegetative cover and topsoil. This can be a long-term problem as some subsurface aquifers produce large amounts of briney or salty water for many years.

Improperly constructed or maintained and abandoned roads can create serious erosion problems.

Section III D of this report lists tables of hazard ratings for benchmark soils occurring in each biome. Hazard ratings include erosion hazard for a bare soil surface and compaction hazard which rates the relative ease of pore space reduction within the soil. These tables and their sources should be referred to for ratings of erosive and compactive actions within each biome. These tables also include a rating for productivity so one may better evaluate what the potential loss is due to vegetative removal.

D. Water

Environmental impacts of oil and gas leasing on water are essentially the same for all sub-biomes. Differences in the nature and magnitude of impacts can occur between phases of oil and gas operations, however.

1. Exploration

The greatest impact of exploration activities on the water resource is the increase in the suspended sediment concentration of streams associated with road construction and the increased travel of vehicles over unroaded terrain. Many of these roads are hastily constructed by tractor. Streams may be forded by heavy equipment. Many of the soils in eastern Oregon produce sediment when vegetation is disturbed and many of the streambanks in this area are in an unstable condition.

Drilling of exploratory wells can leave mud pits located on sites which may slide into streams. The fine silts and clays, caustic chemicals, acids, soaps, oils, and brines contained in the drilling mud will enter the stream where this happens. The silts and clay will increase suspended sediment concentration of the water and can form channel deposits which will be subject to further erosion with each high water event. The remaining pollutants degrade the quality of the water for use as a domestic supply. In addition, many of these chemicals would be toxic to aquatic vegetation at high concentrations. Therefore, some of these pollutants may cause degradation of stream channel vegetation with the risk of increased channel erosion.

2. Development

The development of an oil or gas field will require the construction of additional roads. Many of these may be constructed without proper regard to sediment production or protection of stream banks at crossings. These roads and abandoned exploratory roads will yield suspended sediment to streams. Construction of oil and gas pipelines can also yield sediments to streams in addition to the possibility of oil leaks entering streams.

The construction of sewage disposal systems for crew housing will increase the chance for contamination of streams with sewage effluent. Many of the soils in Oregon are unsuitable for septic tanks because of low permeability and/or high groundwater.

Groundwater aquifers may be penetrated by uncased exploratory wells which can allow brines to contaminate these groundwater supplies. This can be of particular importance in the Klamath area, where much of the stream flow is derived from groundwater. Aquifers along the Columbia and Grande Ronde Rivers could also be endangered by contamination.

3. Production

In addition to the impacts described under Exploration, there can be additional impacts caused by the removal, handling, transportation, and storage of oil and production water from producing wells and separation facilities. Leaks in pipelines can spill oil into surface waters. Corrosion of well casings in producing wells and injection wells can result in contamination of groundwater aquifers. Effects of contamination may not be noted for sometime if the permeable layer intersects a stream a long distance away or if the groundwater pumping well is far

removed from the oil well. If the aquifer is extensive but is not presently utilized, then the potential for future groundwater utilization will be reduced (Environmental Conservation, pgs. 66, 67).

Most of the water use in the refining process is for cooling and condensing. These waters may be subject to contamination with oil through leaks or breaks in pipelines. Smaller quantities of water are used directly in the refining process and the probability is high for this water to become contaminated. The contaminating material may be oil; other petroleum-based toxic substances; chemicals including caustics, acids, and chlorinated hydrocarbons; nitrogen and phosphorous nutrients; and solids such as coke. Many of these substances are toxic. The nutrient materials can cause algal and weed problems in receiving waters. The solids can increase turbidity and many of these substances can cause taste and odor problems in streams (<u>Ibid.</u>).

Most refineries are located along the sea coast, estuaries, or rivers for ease of transportation and also for a ready source of water. The location of refineries close to these bodies of water increases the probability of accidental pollution of extensive bodies of water such as the Columbia River.

4. <u>Abandonment</u>

Breached mud pits can allow sediments to reach bodies of water long after other activity has ceased in the field. Similarly, roads can continue to erode and provide sediment for streams for many years after they have been abandoned. Corrosion of the casings of capped and plugged wells can allow contamination of groundwater reservoirs.

E. Climate and Air

1. Atmosphere

Casual surface exploration using existing systems of unsurfaced roads during dry weather may raise heavy clouds of dust. More significant degradation of air quality may result from actions associated with intensive surface exploration, development of known geologic structures and production of petroleum and gas.

Some impacts can be expected to increase in magnitude as exploration locates and delimits subterranean petroleum reservoirs, and as intensive development leads into large-scale production. Other kinds of impacts may become less significant as operations progress:

- During the construction of access roads and drilling sites in the exploration and development stages, the engines of construction machinery emit exhaust fumes and particulate matter. Dust from construction operations may be heavy locally; in forested areas, the effect may be accentuated by increased movement of air and higher wind velocities in the corridors created by removal of timber. The impact of dust would be especially severe on xeric sites during the dry summer season, particularly during the intensified construction activity of the development stage.
- A blowout during the drilling of a well may discharge natural gases into the atmosphere. These may be odorous or toxic, or both; e.g., hydrogen sulfide. Other blowout emissions are

brackish or saline water, drilling mud and (more rarely) oil, the latter about once in every 5,000 oil sells drilled (Oregon Department of Geology and Mineral Industries, 1972). These pollutants may be sprayed hundreds of feet into the air and, in strong winds, can be carried for distances of more than a mile (BLM Preliminary Draft Environmental Impact Statement - Onshore Oil and Gas Leasing, 1972). The probability of blowouts occurring is greater during development (when numerous wells are drilled within a relatively restricted area) than during exploration, when only a few wildcat drilling attempts may be made on thousands of acres.

- Flaring of natural gas during drilling and testing operations is common. Oil produced during well testing is also burned. Both practices cause some degradation of air quality.
- A blowout can result in a fire when highly volatile hydrocarbons are ignited by contact with hot engine manifolds or sparks from engine exhausts (Ibid.). Such a fire may burn for days or weeks before it can be extinguished, emitting smoke and the products of hydrocarbon combustion into the atmosphere.
- During the refining of crude petroleum in the production phase, sulfur compounds, hydrocarbons, particulates, and odors are released into the atmosphere. Local high concentrations of hydrocarbons are common in the air near oil refineries (Magill, Holden and Ackley, 1956, Sec. 3, p. 13). Evaporative losses from oil storage tanks also contribute to air pollution.

All of these airborne gases and particulates increase to some degree the load of pollutant matter carried by the atmosphere.

2. Micro-climates

In recent years, much has been learned about the micro-climate -- the climate near the ground, immediately surrounding vegetative cover. This climate may be entirely different from the regional macro-climate (Spurr, 1964, p. 15). All oil and gas operations which destroy vegetation (See Sections V G) have potential for altering micro-climates. Such climatic changes can be significant, even if relatively local. The magnitude of the effects of vegetative manipulation will vary with the physical size and density of the vegetation, and with the geographic size of the area treated. These effects are most pronounced when forest cover is removed or added (Zon, 1941, pp. 479-482).

During intensive surface exploration, vegetation is removed when access roads are constructed and trails are cleared for seismic surveys. During this stage of operations, vegetation may also be killed by emissions of toxic gases, saline water, drilling mud and oil from wildcat wells, or by accidental fires.

These same actions, and others, destroy vegetative cover during the development phase. Since this stage of oil and gas operations involves intensified activity concentrated on relatively smaller areas, impacts on vegetation (and hence on micro-climates) will be greater than for exploratory operations. Proliferation of seismic lines on a one-half mile grid, well locations closely spaced, miles of service roads and pipeline gathering

systems, utility lines, separators and storage tanks, and camp facilities cumulatively may cause a drastic reduction of vegetative cover, with resulting micro-climatic changes of great magnitude (U.S.D.I., BLM, Preliminary Onshore Oil & Gas Impact Statement, 1972).

During the production phase, more vegetative cover is lost to installation of oil storage facilities, pressure maintenance systems, secondary and tertiary recovery systems and communication systems.

There is documented evidence of extensive killing of trees, shrubs, and grass resulting from escapement of waste brine from holding pits (Interstate Oil Compact Commission, circa 1965, pp. 26, 27; Montgomery and McGowan, 1971, pp. 229,230). Micro-climate changes following vegetative destruction of this scale could be significant.

Although abandonment of a depleted oil field ends the operational removal of vegetation, there remains a potential for alteration of micro-climates due to the destruction of vegetation by residual brine, oil and acid released by the deterioration of facilities left on site. Pipelines, evaporation pits and dikes, storage tanks, batteries, etc., will be destroyed or weakened by rust, chemical corrosion and erosion with the passage of time after abandonment. The resulting movement of leaked toxic materials by surface flow or leaching through the soil can cause post-operational killing of vegetation and subsequent alterations of micro-climate long after oil and gas operations have ceased (U.S.D.I., BLM, Preliminary Onshore Oil and Gas Impact Statement, 1972).

Contaminants remaining in the soil, and compacted and disturbed soil on and around abandoned drill pads, roads, airstrips and campsites can

inhibit and delay redevelopment of the former micro-climate by precluding revegetation. These residual effects are examined in Section VII of this Statement.

Destruction of vegetative cover during all phases of oil and gas operations, regardless of cause, exposes the soil surface to direct solar radiation and increased air movement and higher wind velocities. On sites so exposed, soil temperatures will be increased, and moisture losses from evaporation will increase. The magnitude of these micro-climatic changes will vary with the vegetative cover characteristic of each of the sub-biomes.

Greatest alteration of micro-climates occurs when heavy forest cover is removed from fairly large areas. The extreme change from closed forest canopies to complete exposure alters local climates most significantly in the Northwest Coastal Forest and Montane Forest sub-biomes. Less pronounced but still significant changes in local climates can be expected in the Broad Sclerophyll following conversion from dense brush cover to complete exposure.

Trees in the Juniper sub-biome are usually widely-spaced and ground cover in juniper stands is often sparse. Under these open conditions, the magnitude of micro-climatic change due to removal of vegetation might be small, with the site regressing from semi-arid to more arid. Greater changes would follow the complete exposure of sites where juniper grows in association with fairly dense ground cover; e.g., sagebrush, bitterbrush, rabbitbrush. Destruction of vegetative cover in the adjoining Cold Desert

would cause micro-climatic modifications similar to those of exposure in the Juniper sub-biome, the magnitude of change varying directly with the size and density of the vegetation removed.

Much of the Palouse Prairie Grassland is under cultivation and has no permanent vegetative cover (Stoddart and Smith, 1955, p. 58). Oil and gas operations would not significantly affect the micro-climates of this portion of the sub-biome. Other parts of the grassland have been heavily invaded by sagebrush and other shrubs (Ibid.). Removal of this vegetation would expose the soil surface to direct solar radiation and induce aridity. Those portions of the sub-biome which retain their original vegetation are covered with bunchgrasses rather than continuous sod. Where this cover is sparse because of heavy grazing and fire, it has been invaded by annuals (Ibid.). Exposure of such sites would probably have only slight impact on micro-climates. Where the original bunchgrass remains it provides some surface shade and reduces surface air movement and evaporation, thus conserving soil moisture. Removal of this cover would lead to a more xeric condition.

Much of the original grass cover in the sub-biome has been converted to production of small grains. When the topsoil on these cultivated areas is dry, strong winds sometimes create extensive dust storms. The same effect would follow oil and gas operations which disturb the surface of the grassland.

F. Vegetation

1. Terrestrial Vegetation

a. General - All Sub-biomes

Impacts on terrestrial vegetation during the exploration stage can occur as a result of (1) surface clearing operations essential to such activities as seismic surveying, stratigraphic testing and wildcat drilling and (2) exposure of vegetation to fire, oil, briny water and toxic gases such as hydrogen sulfide (U.S.D.I., BLM, Preliminary Onshore Oil and Gas Environmental Statement, 1972).

The amount of vegetation destroyed by clearing operations depends on the amount of area disturbed. The area disturbed, in turn, is not always confined to that needed for roads, buildings, flowlines, or wells, etc., due to the action of water-caused soil erosion. As erosion progresses away from the cleared area, it reduces site productivity, thereby reducing vegetative growth, due to "loss of organic matter and nutrients, a break-down of soil aggregates, a reduction in field capacity, a reduction in the rate of infiltration of water, and a decrease in activity of the soil flora and fauna" (Lutz & Chandler, 1965, p. 458). In addition, material carried away from the cleared area can kill vegetation when deposited elsewhere. Factors that govern the extent to which soil erosion may occur are described in Section IV C, "Soils", in this statement. In general, however, "Regions having steep slopes and week, underlying rocks, and a surface bare of vegetation and subject to torrential rains, suffer most from erosion." (Toumey & Korstian, 1956, p. 227).

Another adverse impact associated with surface clearing is reduction of site productivity due to soil compaction associated with the use of heavy machinery. Where compaction occurs, and it is most likely to occur on wet soils, vegetative growth is reduced due to the physical restriction of root growth, reduction of available water for plant growth and reduced water infiltration and permeability. (Thomas, 1970, p. 1).

Site productivity is also reduced on cutbanks and sidecast material where soil humas has been removed or covered by sterile soils from lower horizons, regardless of whether erosion or compaction occurs (Lutz and Chandler, 1965, pp. 181-184).

Exposure to oil or briny water can kill terrestrial vegetation or damage site productivity, reducing growth or delaying establishment of new plants (U.S.D.I., 1972, pp. 112-113; Montgomery & McGowan, 1971, pp. 229-230). Exposure can occur as a result of spills, blowouts, or contamination of underground water zones as toxic liquids rise in uncased wells or test holes contaminating surface waters and vegetation. Toxic liquids may be carried off site by running surface or ground water. (Montgomery & McGowan, 1971, p. 230; U.S.D.I., BLM Preliminary Onshore Environmental Statement, 1972). A similar situation exists in mud pits where leaks, breaks or overflow can cause vegetative kills or reduction in vegetative growth.

Emissions of hydrogen sulfide from stratigraphic tests and wildcat wells and pollutants such as sulphur dioxide, nitrogen oixides, carbon monoxide, and hydrocarbons from burning of liquid or gaseous wastes can

contribute to air pollution (National Petroleum Council, 1971, pp. 29-30, 64). Adverse impacts of air pollution on vegetation are well documented and range from slight injury to complete kill (Air Pollution Control Association, 1970, pp. B1-F11; U.S. Forest Service, 1971).

Wildfires can have severe impacts on terrestrial vegetation. Thousands of acres can be totally denuded in a matter of hours, allowing soil erosion to pollute streams, rivers and estuaries. Soil lost reduces the productive compacity of the burned area. Although fire from blowouts is an obvious threat to terrestrial vegetation, actions carried out during other phases of oil and gas leasing are insidious, but potentially as destructive. For example, dry vegetation can be ignited by crawler tractors, chain saws and other equipment as well as the careless smoker. The threat of wildfire, or "fire danger" varies from little or none during the rainy season to extreme during the dryer period of June through September. Fire danger varies during the June-September period, however, as determined by complex interactions of a variety of factors such as fuel moisture, wind, air temperature, barometric pressure, relative humidity, type of fuel, topography, etc. (Davis, 1959, pp. 189-192). Site productivity may be reduced by fire due to (1) loss of soil nitrogen and other essential elements either directly or through loss of ash by erosion, (2) complete destruction of organic layers lying on rocks or thin layers of loose mineral soil, (3) reduction of infiltration capacity, and (4) erosion following loss of vegetation (Lutz & Chandler, 1965, pp. 309, 372-373).

Since the <u>development</u> phase generally constitutes a period of increased activity in a concentrated area, impacts described for <u>exploration</u> will occur in this smaller area but to a greater degree (U.S.D.I., BLM,

Preliminary Onshore Oil & Gas Environmental Statement, 1972). Additional activity during development, including road, pipeline and facility construction, as well as production well drilling may also mean increased damage to vegetation. Installation of oil storage and transport facilities, pressure maintenance systems, secondary and tertiary recovery systems, and communications systems, disposal facilities and operation and maintenance site construction will add to vegetative destruction.

Greatest impacts during the production phase are most likely to be associated with exposure of terrestrial vegetation to oil, brine and toxic gases due to continued drilling of wells, and disposal of brine, especially if evaporation pits are used. These pits tend to leak or break and may overflow (Interstate Oil Compact Commission, Circa 1965, p. 22). Deterioration of flow lines, valves, pumps and storage tanks and spills of transported oil, are other sources of contamination (Ibid.; Montgomery & McGowan, 1971, p. 230).

Geological subsidence, if significant, could topple forests and expose vegetated areas to erosion and subsequent damage (See Section IV B).

Construction of oil refineries and support facilities will remove additional vegetation. The refinery is a potential source of oil and other toxic element accidental spills (National Petroleum Council, 1971, p. 66). These can destroy terrestrial vegetation and site productivity on and adjacent to the spill site. The refinery is also a source of air pollutants including sulfur compounds, hydrocarbons and oxides of nitrogen and carbon monoxide that can kill or damage terrestrial vegetation (National Petroleum Council, 1971, pp. 69-70). Disposal of solid wastes such as coke fines, clays, catalysts, tank bottom sediments and sludges may require

destruction of terrestrial vegetation where new disposal sites must be developed.

The abandonment phase can also cause destruction of vegetation and reduced productivity of the land as a result of exposure to residual roxic elements released through the deterioration of facilities left on the site (U.S.D.I., BLM Preliminary Onshore Oil & Gas Environmental Statement, 1972). These include pipelines, mud pits, dikes, storage tanks, or reservoirs, batteries, and sumps. Also, abandoned drill pads, roads, airstrips, and campsites can be non-productive sites for many years where concrete or asphalt is used for surfacing. Many non-surfaced areas can also remain unproductive due to severe soil compaction from use of heavy machinery.

All of the preceding impacts may be short term or long lasting depending upon the duration of use and environmental conditions. Impacts related to short duration use, such as seismic testing lines and dry wells, may be of short duration on more productive sites. Long lasting impacts can occur with long term uses such as roads. Impacts of any action may be long lasting if carried out on sites unfavorable for revegetation and rapid growth. Generally speaking, the rate of revegetation and growth will vary extensively within a given sub-biome depending upon the interaction of such factors as elevation, exposure, soil condition, and other factors (Toumey & Korstain, 1956, pp. 14-189). Actions that reduce site productivity, such as soil compaction, fire damage, or contamination by oil and brine may be long lasting.

b. Montane and Northwest Coastal Forest

Impacts related to surface disturbances are important in the mountainous regions of the Montane and Northwest Coastal Forests where steep topography and thin, highly erodible soils and heavy clay soils subject to compaction are common (Ibid.). Timber salvage accompanying clearing operations may require larger, heavier equipment than necessary in other sub-biomes. Consequently, problems of erosion and soil compaction may be intensified in forested areas.

Replacement of the vegetation in these sub-biomes is a long term process under the best of conditions. On warm, dry sites, associated with thin soils and westerly or southerly exposures, development of forests is often delayed for many years while tree seedlings are becoming established (Franklin & Dyrness, 1969, p. 99). Replacement of coniferous forests can also be a long term process on cool-moist sites within the Sitka Spruce Zone of the Northwest Coastal Forest. Here, dense stands of moisture-loving brush and hardwoods may develop rapidly following removal of the coniferous forest, excluding regeneration of conifers for many years (Ibid., p. 49).

Since there are more streams and bodies of water in the Coniferous Forest sub-biomes than other sub-biomes, impacts related to oil and brine water pollution would more likely occur in the Coniferous Forest.

Steep topography and dense vegetation typical of this area (especially the Northwest Coastal Forest) is a severe impediment to fire control. Hence, wildfires occurring as a result of a blowout or other accident can have extensive and devestating impacts on terrestrial vegetation.

The potential buildup of insect populations in logging slash or windthrown trees following land clearing can attack and kill adjacent live trees (Graham, 1952, p. 139). Similarly, oil and gas operations could destroy Port Orford cedar trees, increasing the likelihood that the species will be lost (Roth, Bynum & Nelson, 1972, p. 4; Franklin & Dyrness, 1969, p. 68).

Air pollution associated with refineries located in the Coniferous Forests could cause extensive damage to nearby vegetation.

2. Aquatic Vegetation

Some oil and gas operations adversely affect aquatic vegetation of all types; i.e., floating, submersed and emersed flora. Emersed plants include riparian vegetation which is associated with aquatic ecosystems, such as grasses, sedges and willows.

Construction of roads and survey lines during the exploration phase could destroy aquatic vegetation at stream crossings and in marshes or small ponds by clearing and burying plants growing in the rights-of-way and other construction sites. Such vegetative destruction may be most prevalent during intensive exploration.

Massive land slides triggered by road construction, may enter stream channels and destroy riparian vegetation by scouring stream banks where gradients are fairly steep, and burying downstream vegetation under sediment and debris.

Sedimentation caused by construction during oil and gas operations has a long-term effect on aquatic plants, especially in shallow waters of marshes, ponds and lakes. Heavy deposition of sediments changes habitat conditions by making waters shallow, which accelerates the natural process of plant succession and eventual conversion to land. Some sedimentation in developing ecosystems may be beneficial to aquatic plants. However, in most cases excessive sedimentation is detrimental because it reduces the quality and amount of aquatic habitat.

Major actions that contribute substantial amounts of sediment to surface waters are identified and discussed in Sections IV C, Soils;

IV D, Water; IV F 1, Terrestrial Vegetation; and IV G 2, Aquatic Wildlife. These include construction of roads, camps, and other facilities associated with exploration. Stream crossings, channel changes, gravel removal, disturbance of steep cut banks, steep slopes and unstable areas can cause erosion and sedimentation during construction of roads and pipelines. Heavy precipitation causes additional erosion from these disturbed areas. The resultant sediment load, carried to downstream areas, can kill aquatic vegetation.

Aquatic vegetation can suffer both short and long-term impacts from exploratory actions that disrupt or eliminate the water supply of small springs, marshes or lakes. Drilling of stratigraphic and wildcat wells can alter ground water hydrology reducing aquifer flows (USDI, BLM, Preliminary Onshore Oil and Gas Environmental Statement, 1972). Well drilling requires large amounts of water which may be piped several miles from a stream or pond to the drilling site. Reduction or elimination of the water is shallow lakes, ponds, springs or marshes would adversely effect aquatic plants living in them. Such impacts could happen in water-deficient areas of the Cold Desert, Palouse Prairie and Juniper sub-biomes.

Experiments and studies of accidental spills show that crude oil and distilled products are toxic to plants (Final Environmental Impact Statement Proposed Trans-Alaska Pipeline, Vol. 4, p. 110). Serious destruction of aquatic vegetation can occur from well blowouts during <u>exploration</u> and <u>development</u> phases when oil, gas, briny water and toxic substances in drilling muds enter surface waters. Subsurface

water can also be contaminated by these substances during well blowouts. Contaminated ground water can travel underground several miles before surfacing. Fires started by blowouts, explosions or other accidents can burn riparian vegetation as well as emersed plants in marshy habitats. Release briny water into aquatic ecosystems can also occur as a result of uncased stratigraphic wells.

Increased well drilling activities and intensified construction of roads, pipelines, etc., during the development and production phases can cause increased destruction of aquatic vegetation. Impacts on aquatic vegetationresulting from oil and briny water contamination can become more serious during the production phase as a result of: (1) pipeline leaks in the gathering system and transportation lines, (2) spills, leaks and equipment failures while handling and storing extracted oil, and (3) defective separators and evaporation pits. (Montgomery and McGowan, p. 229).

Transportation facilities, such as a marine terminal, could adversely affect marine vegetation through oil spills during loading, leaks in supply lines to the terminal, tanker accidents in or near the terminal, discharge of oil-contaminated ballast water from tankers, during cleaning and flushing of ship tanks, and discharge of effluent from the ballast water treatment plant at the terminal.

The deleterious impact of an oil spill on marine vegetation depends on the location of spill, magnitude of spill, type of material spilles, and time of contact with the vegetation. An oil spill on the

high seas might not have a large impact on microscopic marine algae because of dispersion and dilution of the material. The same spill in an estuary or inshore area could have a significant, short-term impact on the algae found in all types of habitat (sandy beaches, rocky shores or tidal areas). This would have a short-term impact on all organisms in the food chain since algae are the first trophic level of producers. Low level, chronic oil pollution at the terminal, while not as obvious or spectatcular as a large spill, could have a much greater overall effect on productivity in the estuary than a large spill. Concentrations of hydrocarbons can also be retained and accumulated in the fatty tissues of animals that feed on plankton. Hydrocarbons can therefore be passed up the food chain (Final Environmental Statement - Proposed Trans-Alaska Pipeline, Vol. 4, p. 198).

Crude oil can also damage salt marsh vegetation by smothering. The resultant loss of marsh vegetation can lead to erosion.

Eel grass, one of the most important marine plants found growing in estuaries and along parts of Oregon's coast, has little tolerance to oil (Water Quality Criteria, p. 72). Eel grass is an important part of the intertidal community since it is a food source for black brant. Herring spawn in estuaries adjacent to eel grass and their eggs adhere to its fronds. Many small crustaceans live on it, and certain species of fish and other animals depend on it for food and shelter.

Bull kelp, a large, conspicuous, brown algae which occurs primarily in less than 60 feet of water in favorable habitat off the

central and southern coast of Oregon, provides excellent habitat for many fishes and other marine animals. Photosynthesis in kelp has been found to decrease when exposed to various petroleum products (Environmental Impact Statement Proposed Trans-Alaska Pipeline, Vol. 4, p. 630).

Operation of an oil refinery on or near the coast could add additional pollutants to marine waters. Oils, various chemicals, and toxic substances would all have adverse effects on marine vegetation.

Untreated effluents discharged into estuaries would kill microscopic phytoplankton and larger species such as eel grass. The most severe impacts would occur near the effluent outfall, but the entire estuary would be affected due to the ebb and flood of the tide.

During and after abandonment of a field, oil as well as saline water originating from improperly capped wells or breached mud pits can kill aquatic vegetation (BLM Preliminary Draft Statement - Onshore Oil and Gas Leasing, 1972).

G. Animals

1. Terrestrial Wildlife

a. General - Common to All Sub-biomes

(1) Exploration

Airborne reconnassance flights by fixed wing aircraft and helicopters at low levels can seriously harass and displace migratory waterfowl, wintering big game, breeding animals or birds and nesting raptors, including eagles and hawks. Experience in Alaska has shown aircraft harrassment to cause abortions, desertion of young and other serious impacts on many species of large herbivors. (U.S.D.I., Alaska Pipeline Environmental Statement, Vol. 4, p. 149.) Wildlife at these crucial periods are very vulnerable. Occasional flights by fixed wing aircraft would cause the least disruption, but continued intensive search especially by helicopters could pose a severe hazard to wildlife in the area. Wintering animals could be driven into areas of deep snow, or forced into heavy exertion at a time when all their energy and reserves are necessary for survival.

Wintering and migrating waterfowl congregate in large flocks on bodies of water for resting and feeding, and can be easily harrassed away from these sites by low flying aircraft. This can force the birds into flight to the next body of water that may already be fully utilized by other waterfowl.

Sagegrouse and some other grouse species utilize historic strutting or booming grounds for display and mating activities.

Harrassment of grouse in these areas can result in the disruption of the breeding and nesting sequence and declines in population.

(2) Surface Exploration

Moderate use of existing roads and trails for sampling, surveying, mapping and general reconnassance can be conducted without undue wildlife habitat disturbance. The greatest hazard to wildlife comes from harrassment during crucial periods of nesting, wintering and breeding.

Intensive exploration activities including seismic surveys using explosives, thumpers or vibrators could make an area on/or adjacent to these activities untenable for wildlife, especially endangered species. Destruction of vegetation necessary to wildlife could be of long duration depending on the intensity of the exploration. Use of a thumper -- dropping a 6000 pound steel plate -- could kill small animals and compact and destroy their habitat (Petroleum Extension Service, 1970).

Subsurface exploration involving drilling will make a relatively large area untenable to most wildlife for an extended period of time. A wildcat well site can involve an immediate habitat destruction of one or more areas, plus the room needed for support facilities. Caustic additives used in drilling muds may escape from the drill site and contaminate surrounding vegetation or water in the site vicinity. Acids used to improve casing permiability can also seep from the well and destroy wildlife habitat.

Gas and oil storage tanks may rupture or leak causing damage to vegetation and soil near the wildcat well. Gas flairing

can cause odors and air pollution descernable by wildlife for some distance, increasing the area of wildlife non-use.

A well blow-out with the ensuing discharge of gas, oil, water and other contaminants may adversely affect wildlife habitat for a considerable distance around the drilling site.

The degree and permanence of wildlife displacement or disturbance associated with exploration will depend upon the scope and type of activity. As an example, the noise from testing wells can have a disturbing influence upon wildlife within the vicinity (U.S.D.I. Environmental Impact Statement for Geothermal Leasing, p. 20, 1971).

(3) <u>Development</u>

The hazards posed to wildlife and their habitat by exploration activities are greatly compounded by actual development. Development of a field and related facilities may foster a company town with roads, schools, stores, and dwellings (U.S.D.I. BLM Preliminary Onshore Environmental Statement, 1972). This influx of human activity precludes use of the area for nearly all wildlife. Associated powerlines endanger flying and perching birds through collision with wires while flying and electricution when perching. Small species of mammals, amphibians, and reptiles inhabiting parts of the habitat adjacent to disturbed areas will be endangered by the extensive road systems and traffic. Most of the land within a field would be closed to hunting and other wildlife oriented recreation.

Extensive pipelines and storage tanks, with the increased danger of oil spills and seeps, adds to the wildlife hazard.

Introduction of oil and gas into surface or ground waters can kill birds and animals drinking the water. Oil can also saturate the plumage of waterfowl and shore birds, preventing them from flying and causing eventual death through poisoning or starvation. Lethal effects may occur at a considerable distance from the drilling site. Contaminated water occuring as a by-product of drilling can escape from evaporating ponds or may be introduced directly into streams or other drainages.

Many wildlife species are highly dependent on the vegetation growing in natural drainages. This vegetation provides essential food, and sometimes nesting and escape cover during various seasons of the year. Any activity that destroys this vegetation lowers the quality and quantity of the habitat of ponds, reservoirs, marshes and wetlands essential for waterfowl, shore birds, and many terrestrial forms. Contamination can destroy aquatic, emergent, or floating vegetation or make the water unusable for drinking or food production necessary for wildlife. Loss of habitat from blowouts, spills, leaks, and subsurface contamination, while less dramatic than direct impacts to animals, is usually more serious. Animal populations displaced from an area can eventually be replaced from surrounding ranges provided the habitat remains intact. Destruction of the habitat however, precludes repopulation (ibid.).

Excessive water demands during drilling could lower water tables and drain small ponds or lakes, destroying aquatic plant and animal life, and waterfowl nesting or resting areas. Water run-off from drilling operations can cause erosion and sedimentation of

wildlife habitat. Hot water, often a by-product of drilling, can contaminate surface water, increasing temperatures beyond the tolerance of aquatic plants and animals.

Pipelines constructed above ground and tanks, pumping stations, air strips and camps can impede the free and accustomed movement of wild animals, including migrating species. (U.S.D.I. Alaska Pipeline - Final Environmental Statement, 1972.)

(4) Production

Most of the environmental impacts associated with development also apply during the production phase. Production can be prolinged through secondary recovery by the injection of gas or water into producing wells. This would cause a water shortage for wildlife if surface water is used as the source for injected water. Briney or salty liquids can cause valves and piplines to erode, producing leaks, spills and main pipeline ruptures (Edwin and McGowan, 1972). Trucks or tankers hauling oil can be involved in accidents with impacts ranging from minor to catastrophic. Tidelands and estuaries near tanker routes could be severely affected.

Both development and production may involve many miles of pipeline construction. The presence of heavy equipment, mobile work camps, noise, human activity and accompanying roadways, can drive wildlife out of entensive areas bordering the pipeline. Maintenance of pipeline rights-of-way and haul roads can produce continuing impacts on wildlife through noise, spraying, repair activities, etc.

Presumably refineries would be located along the coast in an estuary, or near the Columbia River in order to take advantage of available water supplies. Since salt water causes scaling and corrosion, fresh water is preferred in refining operations. Wildlife can be adversely affected through direct loss of water from streams and lakes and through lowering of water tables by pumping water from wells. In addition to loss of water, refinery contaminants returned to water sources can reduce oxygen content, affect taste and smell, cause the water to be toxic, add sediments and sludges and increase water temperature. These changes may adversely affect waterfowl, marine and semi-aquatic mammals, amphibians and invertebrates.

Chemical residue from refinery operations can increase air pollution, adversely affecting wildlife.

(5) Abandonment

Impacts on wildlife from abandonment include the potential hazards of animals becoming trapped in open shot holes and sump pits. Oil seepage from abandoned tanks and pipelines could enter and pollute water courses and wetlands.

The following sub-sections cover environmental impacts that are more specific to particular sub-biomes.

b. Cold Desert - Juniper - N.E. Palouse Prairie

(1) Exploration

These sub-biomes are considered jointly since they are mainly elevational differences within the central and eastern

Oregon high desert-Upper Sonoran Zone. Much of the wildlife species and habitat is intermingled. (Bailey, 1936, p. 12)

These semi-desert lands, and adjacent brushlands are crucial to wildlife species for wintering areas, migration routes and breeding grounds, as well as necessary resident habitat. Prospecting for oil in critical habitat areas could have serious adverse impacts. Antelope can be driven from kidding grouns, sage grouse from strutting grounds, and mule deer from accustomed wintering areas. Waterfowl could be driven from breeding and wintering areas and wetlands used during migration. Basic requirements for many species, especially rare and endangered wildlife, are very specific. If their habitat is destroyed, they may not find replacement habitat within their ranging ability. Wetlands, seeps, ponds and reservoirs of high wildlife value in the Cold Desert - Palouse Prairie sub-biomes can become contaminated by drilling effluents which can inhibit or destroy wetland vegetation. Wildlife such as turtles, salamanders, frogs, snakes, ducks, geese, cranes and herons, shore-birds, muskrats, mink, and beaver inhabiting the ponds, and terrestial animals and birds drinking the contaminated water can be adversely affected. Because growing seasons are short, aquatic and wetland vegetation loss can be more serious than the actual immediate loss of wildlife using the habitat.

Intensive test operations that include drilling and heavy vehicle traffic can destroy meadows that are the habitat of many small mammals, reptiles, and ground-nesting birds. Antelope and deer also graze extensively on meadows interspersed within the low sage

and brushland sub-biomes.

Pipelines and roads constructed through fragile desert lands do not readily revegetate. Wind and rain may erode the exposed shallow topsoil along the rights-of-way, retarding or preventing revegetation. Water-born silt from erosion can destroy aquatic vegetation and animal life.

(2) Development and Production

Construction of maintenance and transport roads may open access to formerly inaccessible areas inviting use by tourists and hunters. A disproportonate increase in hunting impact caused by the road network and proximity of permanent or semi-permanent camps can have an extremely detrimental effect on both game and non-game species found in the cold desert habitat. The remoteness and inaccessibility of these areas change immediately with development and production activities. Endangered species such as the peregrine falcon may be further depleted by illegal hunting and nest-raiding by falconers (U.S.D.I. BLM Preliminary Onshore Oil and Gas Environmental Statement, 1972).

(3) Abandonment

The effects of compaction on fragile desert soils can be serious. Abandoned drilling, building, and storage sites will not readily rehabilitate and will be unusable by most wildlife species for a long time.

c. Montane and Northwest Coastal Coniferous Forests

(1) Exploration

Forested areas are susceptable to many of the same

impacts cited for the Cold Desert plus additional ones peculiar to forests. Blowouts in forests can destroy many acres of evergreen and deciduous trees important as wildlife habitat. Forest fires caused by blowouts that catch fire are potential dangers.

The Coniferous Forest contains more streams and waterways than other sub-biomes. Spills of petroleum products, drilling muds, acids, and hot or saline waters can contaminate streams and tributaries and be carried downstream to contaminate estuaries and coastal areas, affecting wildlife in these areas. Losses of water birds that become oil soaked, and marine mammals including sea otters, seals and sea elephants, as well as molluscs and crustaceans can occur. Coastal plant life essential to many forms of wildlife for food and shelter can be killed. Residual affects of contamination can delay vegetative regeneration for a long time (U.S.D.I. Alaska Pipeline Final Environmental Statement, Vol. 4, p. 239, 1972).

(2) Development and Production

Activities associated with development and production of an oil field in the Coniferous Forest could seriously interfere with blacktail deer and Roosevelt elk migration routes and wintering, fawning, and calving areas. Roads, semi-permanent camps, and other development can cause wildlife losses through road-kills, poaching, and intensified hunting. Trenches dug for large pipelines can create hazards to many larger animals, as well as small mammals, reptiles, and amphibians (ibid., Vol. 4, p. 162).

Crude or refined oil shipped from coastal seaports in large tankers run the risk of pollution of shorelands and waters from leaks, pumping of bilges and cleaning of tanks, and shipwrecks (Coans, p. 14-17). Toxic, cancer producing substances contained in oil can have long-term adverse environmental effects where it is spilled. The immediate kill of shallow water marine life may be extensive. Oil contaminants may interfere with nutrient exchange among marine organisms thereby upsetting entire food chains. Chronic pollution of coasts can coat the high-tidal zone and reduce the intertidal habitat. Recovery of the eco-system may be slow. Large spills and chronic pollution of the sea lanes present a threat to certain species of oceanic birds (ibid.).

Semi-aquatic wildlife such as beaver, muskrat, river otter and mink are particularly vulnerable to oil spills (U.S.D.I., Alaska Pipeline Final Impact Statement, page 179, 1972).

Operations that remove timber and brush in the Coniferous Forest and Broad Sclerophyll sub-biomes will have varying impacts on wildlife habitat. These impacts are described in "BLM Timber Management - A Programatic Environmental Impact Statement, Volume 2, Preliminary Draft", pages 253 - 259, 1973.

(3) Abandonment

Because of greater rainfall, more pollutants can be leaked into streams from abandoned sumps and waste pits in forested areas than in the drier sub-biomes.

2. Aquatic Wildlife

Most environmental impacts of oil and gas operations on aquatic wildlife are generally applicable to all biomes. Some of the more serious impacts occur, to a greater or lesser degree, during each of the four stages of operations.

Most streams carry a sediment load due to natural processes of erosion. The following actions during exploration and subsequent phases can cause substantial increases above the natural rate of sedimentation of aquatic ecosystems (USDI, BLM Preliminary Onshore Environmental Statement, 1972).

- Road construction, including clearing of vegetation and soil disturbance. Particularly sensitive areas include steep cut banks along streams and in gullies, gravel removal from streams, relocation of stream channels, and stream fords or corssings without culvert installations. Although road construction usually covers an extensive area once intensive exploration activities begin, the greatest localized impacts occur later in the development stage. Poor planning and duplication of exploration by different companies can result in unnecessary roads (Montgomery and McGowan, p. 229).
- Drilling of stratigraphic and wildcat wells.
- Accidents which result in loss of vegetation; fires, spills, leaks, and blowouts.

Excessive sedimentation by these activities can drastically alter aquatic ecosystems by filling stream channels, estuaries, and the basins of ponds, reservoirs and lakes. These physical changes usually have an undesirable effect on populations of many species of fish and other aquatic organisms that have specific habitat requirements.

Sediment in suspension can kill fish directly by damaging their gills if concentrations are high and exposure prolonged (Phillips, p. 65). Sediment also blocks the transmission of light which reduces algae production and the ability of young salmon and trout to feed. When sediment covers gravel spawning beds, it reduces survival of salmonid eggs and creates a physical barrier which prevents hatched fry from emerging through interspaces between gravels (Ibid., p. 65-67).

Other adverse effects of sediment on aquatic wildlife include reductions in benthic organisms and total productivity, and the interference of feeding and occasional smothering of aquatic invertebrates like mussels or some insects. (U.S. Dept. of the Interior, Final Environmental Impact Statement Proposed Trans-Alaska Pipeline, Vol. 4, pp. 126-127).

In many waters of all biomes, existing conditions are already marginal for the existence of cold-water game fish and anadromous species. Heavy sedimentation of these waters can create conditions that trout and salmon cannot tolerate, resultin gin the elimination of these species from waters they formerly inhabited. Siltation of waterways also discourages recreation and inhibits angling for certain species that are predominantly sight feeders (Phillips, p. 65).

Excessive sedimentation and scouring of stream channels can occur from earth slides. Such slides often originate from roads constructed on steep slopes. During intensive rains, unstable slopes can fail or culverts plug with debris, resulting in tons of soil and debris movement into stream channels. Where this happens most fish and other aquatic life are killed, often for several miles downstream. Of greater impact than the immediate mortality of aquatic life is the loss of the stream's biological productivity due to physical alterations. Destruction of stream banks, scouring of the channel, and the loss of gravel and obliteration of pools can occur. Such events may require decades before the habitat is naturally restored to its former productivity. This type of earth slide is most likely to occur in the Coniferous Forest biome, but steep terrain in other sub-biomes would also be susceptible.

Large quantities of sand and gravel are often required for roads, well sites, and other construction. Direct removal of these materials from streams during exploration would result in loss of fish and other aquatic life and destruction of aquatic habitat. Channel changes in road construction also cause damage to aquatic live and habitat.

A study in Idaho demonstrated that streams with undisturbed natural channels produced eight times greater the poundage of game fish than streams with altered channels (Gebhards, p. 6). Other studies in Idaho and North Carolina showed that the reduction in fish production

due to channel changes is a long-term effect; fish produced remained 80 to 90 percent below original levels after a recovery period of over 80 years.

Road culverts and channel changes during exploration could create impassable barriers for both anadromous and resident fishes. Road culverts are often improperly installed for adequate fish passage -- gradients are too steep creating velocity barriers for fish, conditions at the culvert outfall prohibit fish from entering the culvert, or the water velocities are too great for fish to swim the length of the culvert. Channel changes may also develop velocities that fish cannot negotiate.

Water quality and aquatic wildlife are adversely affected by contamination by oil and gas, briny or salt water, hydrogen sulfide gas, drilling mud, and thermal increases.

Accidents such as well blowouts and spills and leaks of oil begin with exploration activities when wildcat wells are being drilled (USDI, BLM, Preliminary Onshore Oil and Gas Environmental Statement, 1972).

Crude oil contains a water-soluble fraction that is very toxic to fish and other organisms, free oil and emulsions may cover or act on the epithelial surfaces of fish gills which interfers with respiration, and algae and other plankton can become coated and destroyed by oil pollutants. Soluble and emulsified material (including contaminated food organisms) eaten by fish can taint the flavor of their flesh -- hydrocarbons are more responsible for objectionable tastes in fish

flesh than the phenolic compounds. Organic materials may deoxygenate water sufficiently to kill fish, while heavy films of oil on the surface of water can prevent respiration of some aquatic insects and interfers with photosynthesis and reaeration. Oil substances may settle and cover the bottoms of streams and lakes with deleterious effects on spawning areas, eggs and hatching young fish and benthic organisms (U.S. Dept. of the Interior, Water Quality Criteria, pp. 45, 46, and 48; BLM Preliminary Onshore Oil and Gas Environmental Statement, 1972; and U.S. Dept. of the Interior, Final Environmental Impact Statement - Proposed Trans-Alaska Pipeline).

After being deposited on the bottom, oil continues to yield water-soluble substances toxic to aquatic organisms (Ibid., p. 45).

Briny water (20,000 to 100,000 ppm. dissolved solutes) is also a major cause of environmental degradation during oil and gas operations (Montgomery and McGowan, p. 229). Considerable quantities of brine can also be discharged into aquatic ecosystems if accidents occur during drilling. Saline water, oil and gas from blowouts may be blown great distances if strong winds are blowing at the time. (USDI, BLM Preliminary Onshore Oil and Gas Environmental Statement, 1972).

Hydrogen sulfide gas is very toxic to fish. Water contaminated with this gas may enter surface water during well drilling operations or well blowouts. Studies showed the median tolerance limit of unionized hydrogen sulfide for channel catfish fry ranged from 0.8 ppm. at pH of 6.8 to 0.5 ppm. at pH of 7.8 (Bonn and Follis, p. 31).

Bioassays with northern pike revealed that sac fry were less tolerant in a 96-hour test at 6 ppm. dissolved oxygen than were eggs (Adelman and Smith, p. 501). Many of the hatched fry had anatomical malformations and probably would not survive. Other researchers found that juvenile chinook salmon, coho salmon, and cutthroat trout could tolerate without harm only 0.3, 0.7 and 0.5 ppm. hydrogen sulfide, respectively. (Ibid., p. 501).

Caustic additives to drilling mud may get into local waters and drainages during blowouts or when mud pits are breached, allowing the chemicals to pollute surface water (USDI, BLM Preliminary Onshore Oil and Gas Environmental Statement, 1972)

Shallow ground water aquifers can become contaminated by saline water, oil and gas from stratigraphic test and wildcat well drilling. Blowouts can also add pollutants to subsurface supplies of fresh water. Where subsurface formations are permeable and porous, pollutants can be carried many miles before surfacing and contaminating surface waters, affecting aquatic species. (Ibid)

Accidents such as fires, explosions and well blowouts can cause local increases in the temperatures of surface waters affecting aquatic habitat (Ibid.).

Construction of roads, pipelines, crew facilities, storage tanks, separators, dams, pump stations, evaporation pits and drilling production wells during the <u>development</u> of an oil field can contribute more sediment to surface waters. Well blowouts and accidents can

become more numerous than during exploration. Greater quantities of water are also recommended during <u>development</u>. The adverse impacts of these actions on aquatic wildlife has been covered in the preceeding discussion.

During the <u>production</u> phase of an oil field, further adverse impacts on aquatic wildlife and habitat can occur. Continued construction activities can cause further sedimentation. Secondary recovery operations can reduce ground and surface water supplies. Accidents, equipment failures and pipeline leaks have a greater chance of happening.

Extensive use of water can have a pronounced effect on fish and other aquatic species in all sub-biomes. However, the impact of these activities is greatest in the <u>Cold Desert</u> where water and aquatic habitat are in very short supply. There are more rare and endangered fish species in the <u>Cold Desert</u> than any other sub-biome due to isolated ecosystems and harsh conditions. Pollution of a spring or small pond could eliminate an endangered species. Water is also in short supply and degraded quality in parts of the Palouse Prairie, Juniper and Broad Sclerophyll sub-biomes. Additional water use and pollution by oil and gas operations in these areas would have a negative impact on aquatic resources.

Although offshore oil and gas operations are not discussed in this report, a terminal station located at a coastal port in the <u>Coniferous Forest</u>, might be developed to transport either crude or refined oil. Such a terminal and transportation vessel could have

major impacts on marine and estuary resources. Sources of marine oil pollution could originate from the following activities associated with a marine terminal:

- Spillage during cargo transfer and terminal operations.
- Discharge of oil-contaminated effluent from a ballast water treatment facility.
- Discharge of oil-contaminated ballast water from tankers on the high seas.
- Tanker accidents while underway, including grounding and collisions.
- Failures of pipeline systems which spill oil into estuaries or streams flowing into the sea.

Data from major oil spills show that 75% were associated with vessels, 90% involved crude or residual oils, 80% occurred within 10 miles of shore, 75% of the spills lasted longer than five days, 75% were within 25 miles of the nearest port and 85% occurred off areas considered to be recreational (National Petroleum Council, p. 75). For a comprehensive review of information on the impacts of oil on marine organisms, the reader is referred to the Fianl Environmental Statement, Proposed Trans-Alaska Pipeline, Vol. 4 Appendix pp. 621-636, 1972).

Various studies have deomonstrated that oil spills in Oregon's estuaries or coastal waters could have the following deleterious effects (Ibid., pp. 198-205 and pp. 621-633; and Water Quality Studies, pp. 70-73):

- Contamination of plankton and macroscopic organisms results in death and accumulation of hydrocarbons in the food chain and higher species.
- Filter feeders, including important shellfish such as clams, oysters, scallops and mussels could become tainted, restricting their sale and consumption as food items.
- Invertebrates, such as sea urchins and sea stars would be killed.
- Juvenile salmon, trout, shad and striped bass, which spend a critical part of their lives in estuaries before entering the Pacific Ocean, would be deprived of habitat.
- The eggs of forage fish species such as herring, anchovies, and smelt would be very seriously affected. Herring are the most important forage species for large piscivorous fishes and are utilized extensively as bait for salmon, ling cod, flounders, etc.

Although many micro-organisms in both saline and fresh water have the capacity to degrade hydrocarbons, microbial degradation of oil occurs at an unknown rate and its impact on a specific oil spill would be questionable depending on the circumstances (ibid., p. 621).

If significant quantities of oil were discovered in Oregon and it became economically advantageous to refine crude oil in the state, an oil refinery would probably be constructed somewhere on the coast. Such an installation would have an impact on the coastal environment.

Some of the most severe impacts on aquatic fauna would be expected near the refinery effluent discharge. Untreated effluent discharged in an estuary would have a drastic effect on the entire ecosystem of the estuary, resulting in a loss to commercial and recreational fisheries of anadromous and bay species of fish, crabs, and shellfish. Accidents and spills of oil or chemicals at the refinery would increase the deleterious effects on aquatic resources.

Effluent discharged at sea via a pipeline would probably have less direct impact on aquatic life than estuarine discharge. Impacts on marine life would be most obvious in the littoral and intertidal zones. The degree of impact would be affected by factors such as distance the effluent is discharged from shore, depth at outflow and prevailing currents.

Large quantities of water would be used by the refinery, possibly affecting aquatic resources.

Location of a refinery inland, near one of Oregon's larger rivers could occur. Similar water consumption and pollution problems could be expected as previously discussed for a marine refinery. Impacts of oil and other pollutants on fresh water fauna would be similar to those previously discussed. The magnitude of the impact would depend upon various factors, some of the most important being size and location of the refinery, source of water, receiving waters of the effluent discharge, and aquatic resources of the ecosystem.

During and after <u>abandonment</u> of an oil field, breached mud

pits, unplugged wells, holding ponds, and steep cut banks can cause continued sedimentation of streams and lakes. Briney water and oil can also continue to pollute surface waters after abandonment if wells are not adequately plugged or capped.

3. Domestic Livestock

Oil and gas operation impacts on domestic livestock using native range land fall into three categories, 1) the land utilized by improvements or structures which is taken out of production, 2) the disruption of use on surrounding areas because of structures or activity and 3) accidents involving explosions, fires or spills of oil, toxic material or liquid.

The significance of land taken out of production due to improvements or structures depends basically on the inherent productivity of the land. Most range lands support relatively thin stands of vegetation when compared with cultivated lands. Consequently several acres are required to support a cow or its equivalent and a rather extensive area is needed to support an economic livestock operation. The impact of forage loss on livestock grazing due to roads, wells and other development is therefore relatively minor.

Most oil and gas operations have a disruptive impact on domestick livestock. Wildcat well drilling and other exploration activities may adversely affect livestock due to the occupancy of land by roads and cat trails, well site pads, buildings and similar efforts with attendant noise and increased human activity. Construction activity can affect the free and accustomed movement of domestick livestock. Above ground pipelines, tanks, pumping stations, air strips and camps constructed during development and production phases may physically bar or discourage livestock movement because of the associated noise and human activity.

Separation and recovery operations are also noisy and may prevent domestic livestock from utilizing surrounding or adjacent areas. In allotments where intensive grazing management is being applied, disruptive influences may interfere with the proper manipulation of livestock and the accomplishment of vegetation related resource management goals. In most areas disruptive impacts would generally be of moderate consequence and gradually diminish in intensity.

The most serious impact on domestic livestock could occur from accidental blowouts, spills or leaks of oil and caustic, salty or polluted waters. Blowouts destroy vegetation by coating it with oil. Leaks or spills saturate soil and flow or seep into drainages killing vegetation. Oil or other pollutants discharged into natural drainages may sterilize the soil, destroy vegetation and pollute livestock drinking water. Livestock may suffer toxic effects from drinking contaminated water. The volatile portions of discharged contaminants are most toxic to animals and their effects are acute. Direct impacts from the volatile portions of crude oil are generally short term when compared with oil continually draining from oil-saturated soil into water courses.

During the production phase brine evaporation pits containing concentrated salts can poison domestick livestock if used as a drinking source.

Impacts on animals from abandonment of well operations include the potential danger of livestock and other animals becoming trapped in shot holes and sump pits.

H. Micro- and Macro-Organisms

1. Soil Organisms

Populations of bacteria are highest in the surface soil. Actions which remove or destroy the topsoil will adversely affect these populations. Actinomycetes and some fungi have high populations in the sub-soil; however, surface soil removal is detrimental to populations of many fungi, lichens, and algae. Many multi-celled soil dwelling animals depend upon plant debris and organic matter for their food source. Removal of surface soil or destruction of the organic soil fraction will reduce these populations. Certain vertebrates are adversely affected by actions which remove or destroy the topsoil. Their local habitat could be completely destroyed.

Chemical spillage or dumpage will reduce or harm the populations of soil organisms. Fire will also reduce the populations. Areas having heavy spillage or exposed to intense heat may be sterilized for long periods of time. Concrete or asphalt surfacing will inhibit growth and reproduction of many soil organisms. Additions of any degradeable substance to the soil will cause a shift in specie populations. Another example of a specie shift would be the depletion of aerobic organisms and an increase in an anaerobic species when well-aerated soils are flooded.

2. Aquatic Organisms

a. General Impacts

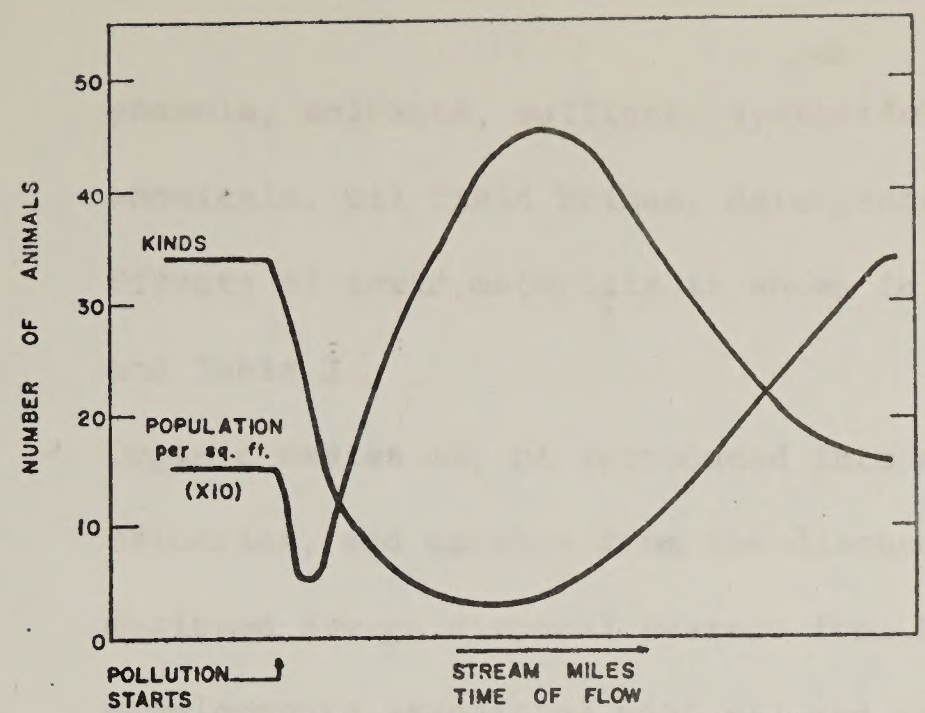
The impacts of oil and gas operations on aquatic organisms may be felt in a number of ways (E.P.A., Freshwater Biology and Freshwater Pollution Ecology, pp. 31-1, 2, 3, 4):

- The depositing of inert precipitates and silt can cause burial and death of vulnerable organisms which may be important fish foods, physical injury to delicate membranes of eyes and gills, and suspended solids can reduce light penetration, suppress photosynthesis and reduce biological activity. The effects of silt on aquatic organisms is shown on Figure 21c.
- The introduction of material with a significant heat content may change the "climate" of a body of water. This temperature change may prevent the reproduction of some typical inhabitants. High water temperatures in winter may cause early emergence of some species with subsequent poor survival, while excessively high summer temperatures may exceed the thermal tolerance of some species.
- Oxygen-consuming materials may deplete the free dissolved oxygen content of water to the danger point for some organisms.
- The introduction of chemicals which may change the pH of aquatic habitat. Aquatic life in relative

abundance and variety can be found in waters ranging from about pH 5 to 9. In some areas thriving aquatic communities may be found in waters with a pH of at least 11. Many species can adjust to pH values over a wide range, however, sudden changes can be fatal.

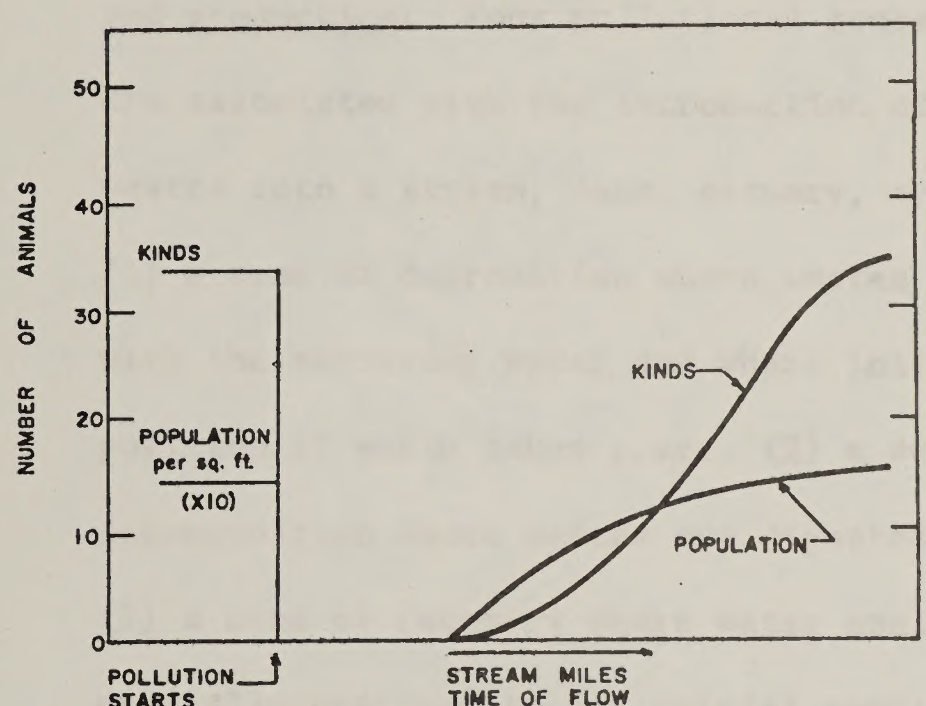
- Chronic or low-level toxicity may change the entire population balance by killing susceptible species, permitting more tolerant species to flourish for lack of competition, and killing algae and invertebrate food organisms.
- Acute or high-level, short-term toxicity may be so broadly effective that many forms of aquatic organisms are affected at one time, or it may be highly selective. It may result from a low concentration of a highly toxic material or a high concentration of a relatively less toxic material. Acute toxicity is frequently encountered as a "slug" resulting from a dump or spill, followed by normal, relatively non-toxic conditions as the mass of water containing the poison flows on downstream, or it may be deflected by tidal movements in an estuary. Examples of chemicals often believed to be involved include: acids, alkalines, ammonia, chlorine, cyanides, metals,

21 a.



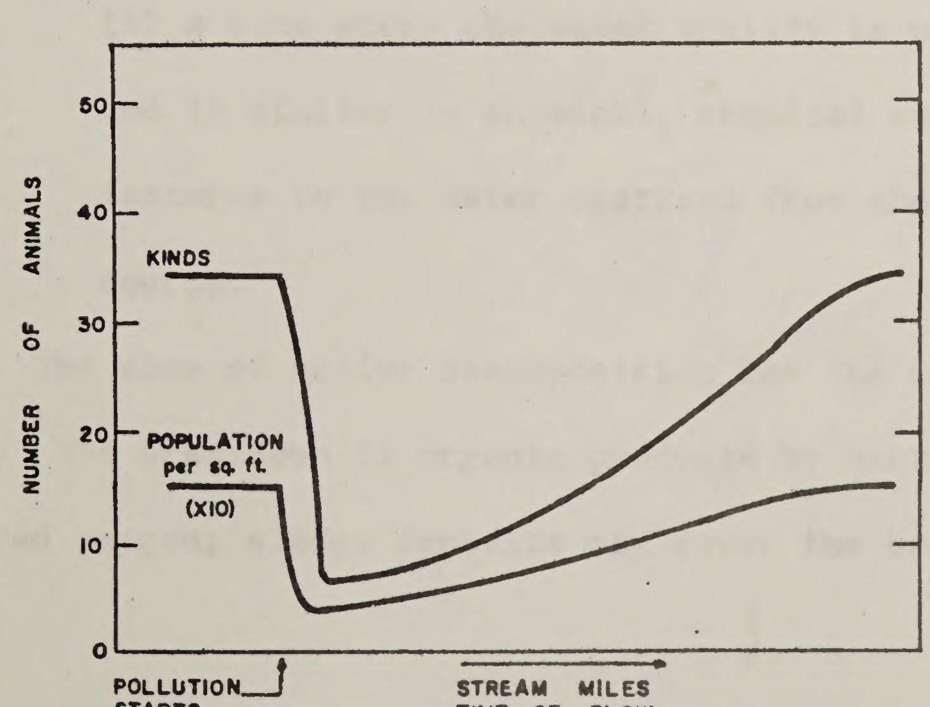
ORGANIC (NON-TOXIC) POLLUTION

21 b.



TOXIC POLLUTION

21 c.



SILT (INERT) POLLUTION

-POLLUTIONAL EFFECTS ON ANIMALS

phenols, solvents, sulfides, synthetic organic chemicals, oil field brines, detergents, and others. Effects of toxic materials is shown in Figure 21b. and Table 1.

- Organic wastes may be introduced into streams, lakes, estuaries, and marshes from the discharge of poorly designed sewage disposal systems from housing developments associated with oil and gas development and production. Four pollutional zones (Figure 22) are associated with the introduction of organic wastes into a stream, lake, estuary, or marsh, (1) a zone of degradation where wastes become mixed with the receiving water and where initial decomposition of waste takes place, (2) a zone of active decomposition where wastes are digested or settled, (3) a zone of recovery where water quality is gradually restored to its initial condition and (4) a zone where the water quality is unaffected and is similar in physical, chemical and biological features to the water upstream from the pollution source.

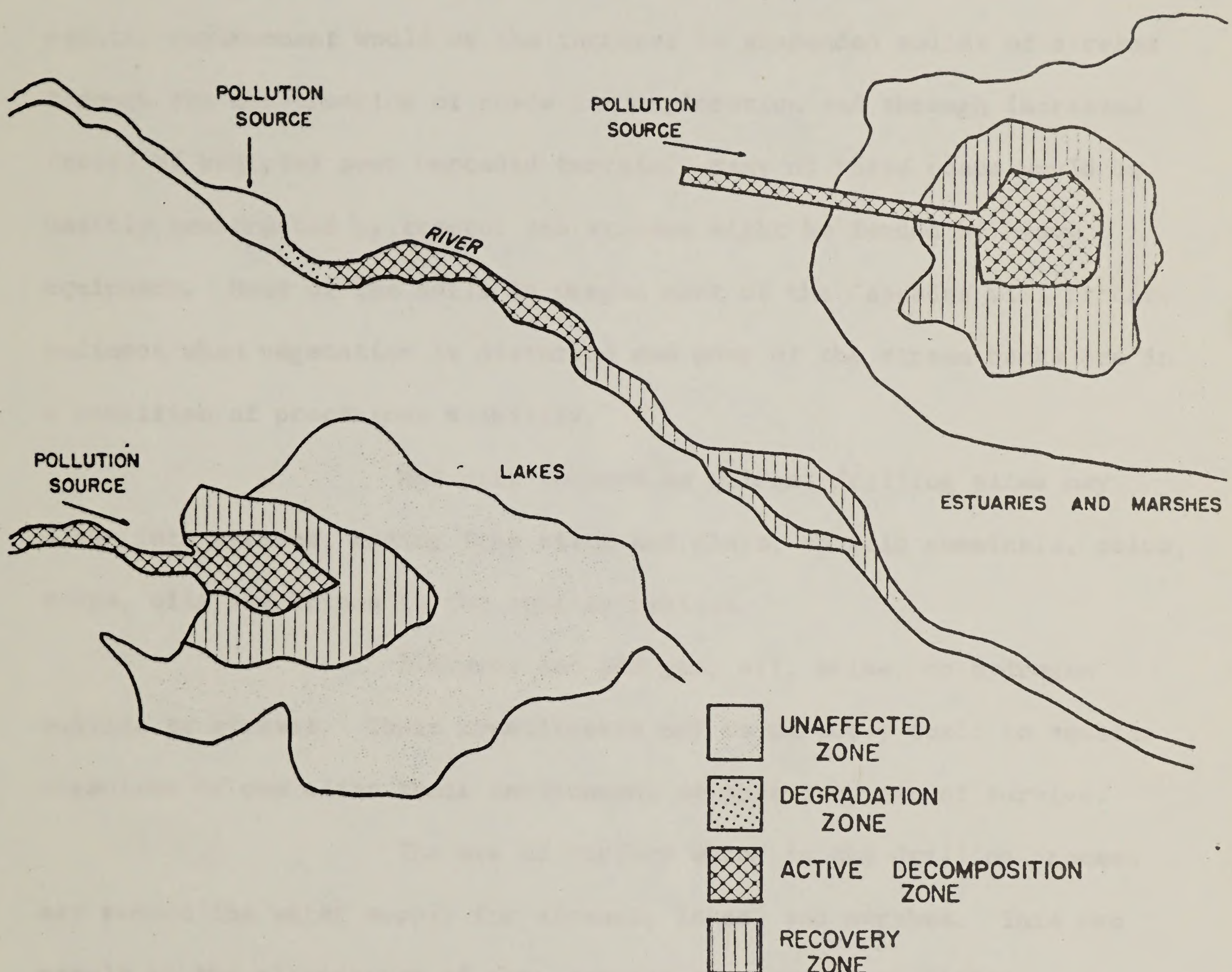
The zone of active decomposition has the worst conditions for aquatic life. The breakdown of organic products by bacteria may consume available dissolved oxygen, sludge deposits may cover the bottom, and

TABLE 1*

INSOLUBLE HAZARDOUS COMPOUNDS

Compound	Physical Characteristc	Hazard
Crude Oil	Varies in color from black, amber red, brown to fluorescent green, asphaltic to H_2S odor; viscous, especially weathered; specific gravity 0.7 to 1.	Aesthetic, toxicity to fish and aquatic biota by smothering or coating; tainting of fish flesh.
Fuel Oil	An entire class of oils, ranging in specific gravity from 0.7 to 0.95; generally brown color; decreasing viscosity, increasing volatility as number decreases.	Aesthetic problem, acute toxicity to fish and other aquatic life; water soluble component toxic to fish food organisms.
Bunker "C"	Viscous dark-colored liquid generally equivalent to a combination of #5 and #6 fuel oil.	Aesthetic problem, acute toxicity to fish and other aquatic biota by coating or smothering, water soluble component toxic to fish food organisms.
Kerosene	Pale yellow to watery white liquid; specific gravity 0.8 to 0.9; generally equivalent to #1 fuel oil.	Aesthetic problem, toxic to fish and other aquatic biota, moderate fire hazard.
Gasoline	Clear aromatic volatile liquid.	Aesthetic effect, iridescent appearance on water in small amounts; acute toxicity to fish and other aquatic life. Soluble and emulsified material may taint fish flesh; low flash point (-46°C), extreme fire hazard.
Benzene	Specific gravity 0.88; solubility 0.07%; colorless liquid with sweetish odor.	Acute fish toxicity in concentrations as low as 5 mg/l; disagreeable taste as 0.5 mg/l; aesthetic effect; flash point -11°C, extreme fire hazard.
Asphalt	Thick, brown to black semi-solid, tarry odor; specific gravity 0.9 to 1.1, negligible solubility.	Toxic to fish and bottom organisms; imports taste and odor; aesthetic effect.

*Adapted from "Water Quality Studies", E.P.A., pages 12-3 and 12-4.



- POLLUTIONAL ZONES FOR ORGANIC WASTES

turbidity may be high. The effect of organic wastes on species and populations is shown schematically in Figure 21a.

b. Impacts by Phase of Operation

(1) Exploration

The greatest impact of this activity on the aquatic environment would be the increase in suspended solids of streams through the construction of roads for exploration and through increased travel of vehicles over unroaded terrain. Many of these roads would be hastily constructed by tractor and streams might be forded by heavy equipment. Many of the soils in Oregon east of the Cascades will produce sediment when vegetation is disturbed and many of the stream banks are in a condition of precarious stability.

Mud pits located on wildcat drilling sites may slide into streams, adding fine silts and clays, caustic chemicals, acids, soaps, oils and brines to the aquatic habitat.

Blowouts can add gas, oil, brine, or hydrogen sulfide to streams. These constituents may be directly toxic to aquatic organisms or can alter their environment so that they cannot survive.

The use of surface water in the drilling process may reduce the water supply for streams, lakes, and marshes. This can result in the elimination of some species or entire communities.

(2) Development

The development of an oil or gas field will require the construction of additional roads. Many of these may be constructed without proper regard to sediment production and protection of stream

crossings. These roads, and many of the abandoned exploration roads, will yield suspended sediments to streams. The construction of oil and gas pipelines can also yield sediment to streams.

The development of housing can introduce sewage and kitchen wastes into streams as a result of poorly designed sewage disposal systems. Many soils are unsuitable for septic tanks because of low permeability and/or high groundwater.

(3) <u>Production</u>

The removal, handling, transportation, and storage of oil and production water from producing wells and separation facilities can cause further degradation of aquatic habitat. Much of the production water is saline and this can eliminate or reduce aquatic species and populations if allowed to enter streams, lakes, or marshes.

Injection of saline production water into wells may result in leakage of this water to streams through porous strata long distances from the injection well. The use of groundwater for injection may reduce the flow of springs which supply streams, lakes, or marshes. This reduction in water supply may be critical in semi-arid areas.

The effects of the degradation of water quality by pollutants from refineries is described in Freshwater Biology. In addition, many species and populations or organisms in receiving waters may be eliminated by the toxicity of these contaminants. The higher temperatures of water which has been used for cooling may exceed the

thermal tolerance for some organisms. Conversely, the warmer water may create better conditions for some organisms which may become dependent upon this new environment for their survival. These organisms may be eliminated during those periods when the refinery is shut down. Most refineries are located along the sea coast, estuaries, or large rivers. Therefore, the probability is increased for damage to aquatic organisms through leakage of petroleum products.

(4) Abandonment

Breached mud pits can allow sediments to reach bodies of water long after other activity has ceased in the field. Flowing wells may leak brine into streams, lakes, and marshes.

I. Social, Economic and Land Use

1. Health and Safety

Oil and gas operations, in common with all industrial activity, can have direct impacts on the health and safety of industrial personnel. Accidental death, maiming and adverse health conditions can occur. Casualty potential begins with the first phases of exploration and continues through the production phase as indicated in Table 1 on the following page.

Some of the hazardous operations and conditions associated with oil and gas activities include low level exploratory aircraft flights, use of explosives, travel on low standard and primitive roads, and the drilling operations (the most hazardous phase as shown in Table 1). Cleaning of tanks, high pressure gas lines, and exposure to toxic and irritant gases from refinery operations can also be hazardous.

Population in most prospective oil and gas areas in Oregon is characterized by very low density; with slow or zero growth rates. Discovery and development of oil and gas in these areas would result in significant population increases. For example, population density in San Juan County, New Mexico, increased from 3 to 10 persons per square mile from 1950 to 1960, following oil development (U. S. Bureau of Census, County and City Data Books 1950-1960). Depletion of reserves and abandonment of activity could result in a correspondingly drastic drop in population.

Although it is doubtful that refinery sites would be established in any rural Oregon locations since these areas lack most of the features

of an ideal site (See Part II. B. 3), development of a refinery would create social and economic impacts of greater magnitude than development and production alone. Typical employment would run from 100 to 200 people, with an expectent increase in local general service and trade employment. Abandonment of fields supplying the refinery would cause a severe local reduction of economic activity if other sources of supply were not found. Development of access roads and trails during the <u>exploration</u> and <u>development</u> stages can create hazardous situations for the general public. Off-road vehicle enthusiasts operating on low standard, non-maintained seismic roads and trails can unexpectedly encounter wash-outs and slides that can result in injury or death. Dams, separation ponds, liquid waste disposal areas, exploratory roads and surface pipelines all pose hazards to the recreationists or inquisitive vistitors in the area. Abandoned roads and air fields deteriorate rapidly, causing potential hazardous situations to the uninformed. Accidental explosions and fires could cause substantial damage to private lands and property and death and injury to nearby residents. Blowouts, oil spills and leaks, or less detectable seepage of waste waters carrying toxic compounds, can contaminate domestic water supplies. Toxic or irritant gases caused by refining can also pose a hazard to the general public.

2. <u>Social and Economic Factors</u>

a. <u>Social</u>

Adverse social impacts of exploration and development would be most significant in those areas characterized by a stable rural economy (typically farming, ranching, or forestry), and where significant

mineral-based economies are absent.

Area residents adversely affected would be those who place a high value on the stable life styles common in rural areas and those who would not derive direct economic benefits from development.

Development could place a severe initial strain on local government. Additional demands would be placed on schools, medical facilities, police and fire departments, and utilities. Typically, additional services may not be provided and the quality of service for all suffers.

b. Employment

The largest need for employment occurs during discovery and development of an oil-gas field. It is estimated that in most cases local labor is used for 10-15% of the field crew employment (road building, drilling, etc.). It is normal practice for oil companies to retain local semi-skilled labor hired during development, train them, and utilize them during the production phase.

Assuming a fairly large discovery, the overall impact on local employment would be moderately beneficial. The magnitude of the impact would vary with the unemployment rate of the area prior to the discovery.

Employment opportunity would, of course, cease as a field is abandoned.

c. Local Economic Growth and Stability

Large oil discoveries generate a sudden and sizeable expenditure of capital and demand for services. Service and trade sectors

are inflated immediately, creating secondary employment. Increased demand for land would typically occur, appreciating local real estate values.

Economic activities would slow down during production phase and further taper off as the field was abandoned. Although initial impact generated is sizeable, it occurs so rapidly it is apt to be unstable. Large fields which are quickly depleted would establish an economic pattern detrimental to long-range needs of an area.

Because of the numerous uncertainties connected with development in areas where oil and gas does not now make up a significant portion of the economy, the local economic benefits of leasing are judged to be minor.

One of the most important economic factors is the return of royalties and taxes from oil and gas production to state and local governmental units. This factor is most significant to areas and states which are sparsely populated and lack an industrial base, providing inadequate tax sources.

In 1967, in Wyoming, the various state taxes and royalties and the state portion of Federal royalties an oil and gas production totaled nearly 59 million dollars (Cameron Engineer - 1969). On a per capita basis, this would be approximately 177 dollars for each man, woman, and child in the state (1970 population).

In areas with low tax base, this revenue source is very significant in financing public services and facilities.

3. Land Use

Development of an oil and gas field for production introduces a land use which is quite intensive, and, in some respects, very restrictive with regard to other uses which may occur.

Significant adverse land use impacts can occur in areas which have not adopted and implemented comprehensive land use plans so that oil and gas development can be integrated with long-range objectives for the area. Following are some of the major land uses which may be affected by oil and gas development:

a. Wilderness (including potential wilderness)

All phases of oil and gas operations would have significant adverse impact on wilderness lands. Each phase involves access, human activity, or development which is in conflict with wilderness objectives.

b. Mining

Exploration, development and production operations under an oil and gas lease can preclude the development of other mineral resources.

Construction and operation of oil tank farms, battery and pump stations, oil collection and transportation lines and electric transmission lines associated with an oil or gas field would seriously curtail exploration for other minerals in their vicinity. Blasting would be prohibited due to the possibility of rupturing pipelines and oil storage tanks and breaking powerlines. Off road travel would be

limited by surface obstructions such as pipelines and mud pits, well heads, etc.

Roads, trails, airstrips and other facilities left after abandonment of oil and gas operations could benefit exploration and development of other minerals.

The presence of electric transmission lines could provide a ready source of power for development of minerals other than oil and gas in the abandoned operational area. Similarly, abandoned tanks and pipelines might be used in mining operations for the storage and transportation of water and other chemicals.

c. Forest Products

Facilities required for oil and gas development and extraction would take some forest land area out of production and could place constraints on timber harvest during development and production phases, and on forest regeneration following abandonment. In isolated timber areas roads developed for oil and gas operations could also be used for timber management and harvest.

d. Recreation

All phases of oil and gas operations affect, to some degree, recreation uses and values. Construction of facilities changes the appearance and character of the land. Where development occurs, land will be removed from recreation use. Public access, unless closely supervised, would likely be denied to operating fields because of possibilities of vandalism and injury.

Adverse impacts will be significant if oil and gas activities take place in areas of intensive recreation use, or areas of rare and unique resource values.

Recreational uses which depend on motorized travel to get to an area of interest could benefit because of improved access. Fishing, hunting, rockhounding, and off-road vehicle uses are examples. Better access, however, could adversely affect some resources because of overuse and crowding.

e. Agricultural

Oil and gas operations can remove agricultural land from production and distrupt agricultural activities on surrounding land. The magnitude of this impact depends on the productivity of the land removed from agricultural use. The impact of forage loss on livestock grazing lands caused by roads, wells and other development will normally be minor. The effect on naturally productive soils or lands with large agricultural investment could be significant. Livestock grazing may be adversely affected by intensive activity associated with a developing field. Historical or seasonal patterns of use may be distrupted. In cultivated areas, construction of structures and improvements can interfere with normal farm field operations.

f. Residential, Commercial and Industrial

All phases of oil and gas operations would introduce very disruptive changes in urban areas. The prospect of fires, blowouts, and subsidance, together with the obvious land use conflicts, poses impacts of extreme magnitude.

J. **Aesthetics and Human Interest Values**

1. Impacts Common to All Sub-biomes

a. Aesthetics

(1) Visual

Basic elements of the visual landscape can be altered by removing vegetation or soil and by placing structures where there were none before. Areas that are still in a near natural condition would suffer the greatest visual impacts from oil and gas operations.

Exploration activities take place over large areas of land and although they may disturb relatively little of the total acreage, the effect on the visual environment can be devastating. In the past, seismic exploration has been responsible for the major visual impact, particularly in areas that were in a near-natural condition. The criss-cross pattern of cleared vegetation made by a dozer interrupts the texture and color of the vegetation and superimposes unnatural lines on the land form. This impact might be short-lived in the Grassland, but in the Desert or Coniferous Forest it may be a near permanent scar.

Access roads, drill pads and impoundments needed for wildcat drilling all have serious, although fairly localized, impacts on the landscape. Because both vegetation and soil are disturbed, there is a potential for long-term impact in all of the biomes. Erection of a drill rig, even though it is temperory, imposes a large vertical structure on a relatively flat plane in some areas and attracts the eye from a great distance.

Fires, spills, and blowouts may leave lasting scars in the form of denuded vegetation, sterile soils and deposits of oil or other chemicals on the surface. Human activities associated with oil and gas exploration bring litter and waste materials along with some destruction of the surrounding environment.

The visual impacts of the <u>development stage</u> are similar to those in exploration. There may be additional seismic exploration activity creating more seismic trails, more closely spaced and often running diagonal to the original lines. This additional disruption of the vegetation would have a definite visual effect in all sub-biomes.

The construction of additional roads, trails, and well pads during development removes more vegetation and involves a considerable amount of soil movement. The introduction of pipelines, both surface and buried, and electrical transmission lines, tank batteries, pump stations and treatment facilities, all add to the visual impact.

The visual impacts associated with accidents, spills, and blowouts are much the same as for exploration, except that the opportunity for such accidents is increased during development. Discovery and development of a field will also increase exploratory acitivities, including wildcat drilling, in surrounding areas adding to the visual impact.

The visual impact caused by <u>production</u> will not increase greatly over that which is caused by development. There may be some increase in surface structures and some additional pipelines, particularly where secondary recovery methods are undertaken. The tall

drill rigs will no longer be evident at this stage. Therefore, there will be somewhat less vertical intrusion on the landscape.

The visual impact from refineries could be very great if they were located on open, flat landscape, such as along the Columbia River. Location along the coast would create less of a visual contrast, but would still be an instrusion unless located in areas already developed to heavy industry. Cooling towers being incorporated into modern refineries would stand out regardless of location. Smoke, fumes, coke dust and other airborne pollution would effect visual esthetics.

Abandonment of oil production facilities may have both positive and negative impacts on the visual environment. Natural regeneration of ground covering vegetation will tend to reduce the impact of disturbed soil areas. On the other hand, with the roads no longer maintained, the opportunity for soil erosion will increase, leaving more surface scars. Facilities that are left will fall into disrepair and take on a shabby appearance. Eventually, an abandoned oil field may return to near natural condition. This will take much longer in the dry areas of eastern Oregon than in the Coniferous Forest.

(2) Sound, Smell

The noise levels associated with exploration activities may be quite high in a local area, but would normally not carry any great distance. Smells would be very minor and would have no significant impact on the existing environment. With the concentration and increased activity of the development phase, the noise levels from

from trucks, heavy machinery and drilling rigs will be increased and the area affected will increase. At this stage there should be very little additional impact from odors.

The noise levels will probably not change greatly in the production stage. However, noise will vary, depending upon what type of pumping facilities are used and whether or not they are housed. There may be a marked increase in the production of noxious odors at this stage, depending upon the type of oil being produced, and how much is exposed to the atmosphere and how the gases are being disposed of.

Refining operation would have effects on both noise levels and odors. Noises associated with moving fluids within the process system, high velocity jets of gas or vapor discharging into the atmosphere, mechanical equipment, and combustion processes would be present. Malodorous gases and vapors escaping from refining operations could have severe impact on olfactory senses.

After abandonment, there should no longer be any impact from sound or smell with the possible exception of refineries which may continue operation if other supplies can be found.

b. Geological Values (Human Interest)

Geological values are susceptible to alteration and destruction as the result of exploration activities that destroy or impair their value as human interest subjects. Activities using thumpers, vibrators and explosives, when done above delicate geological features

like caves, or near erosional features such as natural arches, can damage or destroy them. Activities involving substantial earth-moving can produce ill effects on visually important geologic features by altering or obliterating them.

Structures placed in close proximity to unique geologic features tend to distract from their human interest value. A drill rig next to a photogenic feature is an example.

Some types of geological phenomenon, such as fossils, may be illegally removed by oil and gas exploration crews, oil field workers, and the general public using oil industry roads to gain access. Vandalism may destroy values that cannot be removed, such as petrified tree remains.

c. Archeological Values

Archeological sites are most valuable to both the scientist and the sightseer when they are undisturbed. Any type of excavation, earth movement, or soil compaction in and around an archeological site can reduce or destroy the values the site contains. Soaking with fluids such as saline water or oil will reduce the archeological value of the site. Wooden structures and dry caves are susceptible to fires. Providing access for vandalism and looting is a major source of impact.

Roads and trails constructed by seismograph and development crews may cut through archeologic sites. Excavations for drill pads, camps, borrow pits, roads, etc., can do the same. Seismic

test shots and the use of thumpers and vibrators close to archeological caves, walled structures and on top of sites can cause irrepairable damage to archeological values. Wooden structures and dry caves with quantities of flammable material are apt to be destroyed by fires started through oil and gas activities. Pipeline excavations may cut through surface sites. Activities at some distance from archeological sites may trigger erosion which can remove the site or cover it.

On the otherhand, valuable, unknown archeological sites can be discovered during exploration and development operations.

d. Historical Values

Oil and gas exploration activities can be detrimental to historical values if the activities occur on historical sites or near historical structures. Both research values and sightseeing recreation values can be destroyed by construction activities, accidental spills of oil or caustic chemicals, fire and well blowouts, and by vandalism. Use of historic trails by heavy equipment can obliterate their historic value.

Shot holes drilled along trails, near structures, and on other sites can destroy the historic atmosphere by introducing foreign and disturbing elements to the scene. Thumpers, vibrators and explosives used near historic structures can weaken or destroy them. New roads and trails can detract from the mood generated by historic sites.

Introduction of oil industry workers and improvement of access to the public increases the possibility of vandalism to historic

sites. Structures may be dismantled for their weathered boards, used for temporary shelter or storage, or burned. Holes may be dug in the ground to recover bottles and other souvenirs.

e. Cultural, Ethnic and Religious Values

There are two basic items concerned with impact under the subject heading, i.e., impact on specific sites and the impact on the life style of the group. There can be sites of religious, mythological, subsistance, historical, symbolic, sentimental, or even imagined significance to the local population of an area. These sites and areas are similar to archeological and historic sites for purposes of impact evaluation.

Impact on life styles is difficult to assess in many cases for much of it is psychological and the values under impact are judgment values whose rationale is not necessarily logical in terms of the majority culture.

People problems can become acute particularly where local tolerance for those who deviate from predetermined social and religious patterns is not too great. Much of the exploration phase and, to some extent the other phases, tends to be dominated by single men and the image with which they identify is the hard-working, hard-drinking machismo male. This runs counter to values of many of the local cultures and sub-cultures scattered over the state.

New dollars are probably the greatest impact, expecially in areas of low income. Low income local residents may use the new

income to try and imitate the transient culture, acquiring superficial material items in an effort to "keep up with the Joneses".

As the new dollars later dwindle with reduced production and abandonment of the field, cultural instability can set in. Individuals unable to cope find themselves in limbo, unable to unwilling to return to the old culture and unable to follow the new. Consequently, a great many social and mental health problems can be created by the impact of the oil and gas industry on native Americans; and, to a lesser extent, other cultural groups.

Some of the positive impacts are the potential for raising the standard of living, asperations, and level of achievement of local groups.

2. Unique Impacts by Sub-biome

a. Palouse Prairie Grassland

(1) Aesthetics

The gentle slopes of the grassland require less movement of soil for road and drill site construction and maintenance than the other sub-biomes.

The lack of high vegetation and the low relief profile make it possible to see considerable distances in the grasslands. This makes any surface disturbance quite obvious over a wide area. The lack of vertical elements in the natural landscape make tall, man-made structures inordinately obvious.

(2) Archeologic and Historic Values

The flat grasslands were traversed extensively

by early natives and pioneer settlers. Remnants of many of these old trails still exist. Exploration and development on the grasslands can damage and obliterate these trails.

b. Cold Desert

(1) Aesthetics

Desert land forms are characterized by broken, stark relief. Because of this, many of the operations involving the movement of earth will create larger, more visible scars.

Regeneration of disturbed vegetation takes longer in the arid environment of the desert than elsewhere. Operations which remove the vegetative cover are, therefore, of greater impact.

In many areas of the desert, the color of the soil surface and rocks is the result of long years of weathering and chemical interactions. When the soil surface is disturbed, the contrast is stark and may remain so for many decades.

c. Juniper and Broad Sclerophyll

(1) Aesthetics

Most of the impacts in the Juniper and Broad Sclerophyll Sub-biomes are much the same as those in the desert. In some areas the impacts may be more obvious because of the density of the vegetation. Because of the higher rainfall, removal of vegetation and soil disturbance caused by construction could create severe erosion problems.

d. Coniferous Forest

(1) Aesthetics

The steepness of the terrain, along with the high profile in the coniferous forest, creates a situation where seismic lines, pipelines and roads running perpendicular to the slope are visible for extremely long distances. Clearing the vegetation subjects the steep slopes to erosion that can strip the shallow soils and prevent revegetation. The steep slopes also make larger cuts and fills necessary for the construction of roads and drill pads.

REFERENCES CITED

1. Adelman, Ira R. and Lloyd L. Smith, Jr., Effect of Hydrogen Sulfide on Northern Pike Eggs and Sac Fry, Transactions of the American Fisheries Society, Vol. 99, No. 3, 501-509, July 1970.

2. Air Pollution Control Association, Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas, Pittsburgh, Pennsylvania, 1970.

3. Anonymous "Environmental Conservation, The Oil and Gas Industries", Vol. One, A Summary, Washington, DC, June 1971, pp. 106.

4. Anonymous "Freshwater Biology and Freshwater Pollution Ecology", Environmental Protection Agency, Pacific Northwest Region, Corvallis, Oregon, June 1971.

5. Anonymous "Water Quality Studies", Environmental Protection Agency, Pacific Northwest Region, Corvallis, Oregon, March 1971.

6. Bonn, Edward W. and Billy J. Follis, Effects of Hydrogen Sulfide on Channel Catfish, Ictalurus Punctatus, Transactions of the American Fisheries Society, Vol. 96, No. 1, pp. 31-36, January 1967.

7. Brochett, E.D., H. Athue Jr., and V.M. Brown, 1971. Environmental Conservation - The Oil and Gas Industries, Vol. 1 - A Summary, National Petroleum Council, Washington, DC, pp. 106.

8. Burroughs, E.R., Jr., G. Chilfant, M. Townsend, 1973. Guides to reduce road failures in western Oregon. U.S. Dept. of Interior, Bureau of Land Management. (In final stages of preparation).

9. Coan, Dr. E., Oil Pollution, Sierra Club Bulletin, pp. 14-17, March 1971.

10. Darling, F. Fraser and Milton, John P., 1966, Future Environments of North America, The Natural History Press, Garden City, N.J., pp. 767.

11. Davis, Kenneth P., Forest Fire: Control and Use, first edition, 1959.

12. Franklin, Jerry F., and Dyrness, C.T., Vegetation of Oregon and Washington, U.S.D.A., Forest Service Research Paper, PNW-80, Portland, Oregon, 1969.

13. Fredriksen, R.L., 1970, Erosion and Sedimentation Following Road Construction and Timber Harvest on Unstable Soils in Three Small Western Oregon Watersheds, U.S.D.A., Forest Service Research Paper, PNW-104, Portland, Oregon, pp. 15.

14. Gebhards, Stacy, The Vanishing Stream, Idaho Wildlife Review, March-April 1970, pp. 3-8.

15. Graham, Samuel A., Forest Entomology, third edition, 1952.

16. Interstate Oil Compact Commission, Water Problems Associated with Oil Production in the United States, Oklahoma City, Oklahoma, 1965.

17. Kormondy, Edward J., 1969, Concepts of Ecology, Prentice-Hall, Inc., Englewood Cliffs, N.J., pp. 209, illus.

18. Lull, H.W., 1959, Soil Compaction on Forest and Range Lands, U.S.D.A. Misc. Publ. 768, pp. 33.

19. Lutz, Harold J. and Chandler, Robert F., Forest Soils, tenth printing, 1965.

20. Mackenthum, K.M., The Practice of Water Pollution Biology, Environmental Protection Agency, Pacific Northwest Region, Corvallis, Oregon, 1969.

21. Magill, Paul L., Holden, Francis R. and Ackley, Charles, 1956, Air Pollution Handbook, McGraw-Hill Book Company, Inc., New York, NY.

22. Marsden, S.S., Jr., and Davis, S.N., Scientific American, June 1967, Vol. 216, No. 6, p. 93.

23. Maunder, W.J., 1969, Pollution, p. 114, University of Victoria, Victoria, B.C.

24. Montgomery, Edwin H. and McGowan, Terry A., 1971, The Environmental Impact of Oil and Gas Development on Public Lands, Paper No. EQC45 prepared for Extractive Industries of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., New York, NY, June 1971.

25. National Academy of Sciences, National Academy of Engineering, Earthquakes Related to Reservoir Filling, 1972, Division of Earth Sciences, National Research Council, 2101 Constitution Avenue, NW, Washington, DC 20418, pp. 24.

26. National Petroleum Council, Environmental Conservation - The Oil and Gas Industries, Volume One, prepared by the Council's Committee on Environmental Conservation at the request of the Dept. of the Interior, June 1971.

27. National Petroleum Council, Environmental Conservation - Gas and Oil Industries, Vol. II, pp. 399, 1972.

28. Odum, Eugene P., 1959, Fundamentals of Ecology, W.B. Saunders Co., Philadelphia, PA, pp. 546, illus.

29. Oregon Department of Geology and Mineral Industries, 1972, Analysis of Oil and Gas Development (draft), pp. 16, illus., Portland, Oregon, June 2, 1972.

30. Petroleum Extension Service, A Primer of Oil Well Drilling, 3rd Edition, University of Texas, Austin, pp. 81, 1970.

31. Phillips, Robert W., Effects of Sediment on the Gravel Environment and Fish Production, Proceedings of a Symposium of Forest Land Uses and Stream Environment, Oregon State University, August 1971, pp. 64-74.

32. Roth, L.E., Bynum, H.H., and Nelson, E.E., Phytophthora Root Rot of Port Orford Cedar, U.S.D.A., Forest Service Forest Pest Leaflet 131, 1972.

33. Spurr, Stephen H., 1964, Forest Ecology, The Ronald Press Co., New York, NY, pp. 352, illus.

34. Steinbrennet, E.C., and S.P. Gessel, 1955, Effect of Tractor Logging on Soils and Regeneration in the Douglas-fir Region of Southwestern Washington, Soc. Amer. Foresters Proc. 1955, pp. 77-80.

35. Stoddart, Laurence A. and Smith, Arthur D., 1955, Range Management, McGraw-Hill Book Co., Inc., New York, NY, pp. 433, illus.

36. Storer, John H., 1953, The Web of Life, The New American Library, Inc., New York, NY, pp. 126, illus.

37. Stormont, D.H., Water Conservation, California Style, Oil and Gas Journal, March 28, 1966.

38. Thomas, Byron R., Tractor Logging and Soils Compaction, A Review of the Available Information, A Report to State Director, Oregon, Bureau of Land Management, 1970.

39. Toumey, James W., and Korstian, Clarence F., Foundations of Silviculture, second edition revised, 1956.

40. U.S.D.I., Draft, Environmental Impact Statement for the Geothermal Leasing Program, pp. 48, Washington, DC, 1971.

41. U.S.D.I., Final Environmental Impact Statement Proposed Trans-Alaska Pipeline, Volumes 1-6, 1972, prepared by a special interagency task force for the federal task force on Alaskan oil development.

42. U.S.D.I., Bureau of Land Management, 1972, Preliminary Draft - Timber Management - A Programmatic Environmental Impact Statement, Washington, DC.

43. U.S.D.I., Bureau of Land Management, 1972, Preliminary Draft - Onshore Oil and Gas Leasing Programmatic Environmental Impact Statement, Washington, DC.

44. U.S.D.I., Water Quality Criteria, Report of the National Technical Advisory Committee, Federal Water Pollution Control Administration, April 1, 1968, Washington, D.C., Section III - fish, other aquatic life, and wildlife, pp. 28-106.

45. U.S. Forest Service, Southeastern Area, Air Pollution and Trees, Atlanta, Georgia, 1971.

46. Weaver, John E. and Clements, Frederick E., 1938, Plant Ecology, McGraw-Hill Book Co., Inc., New York, NY, pp. 601, illus.

47. Zon, Raphael, 1941, Climate and the Nation's Forests, in Climate and Man - Yearbook of Agriculture, U.S. Government Printing Office, Washington, DC.

A P P E N D I X

EXHIBIT 1

FORMAT FOR ENVIRONMENTAL ANALYSIS RECORD

Title:

1. DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

2. DESCRIPTION OF THE EXISTING ENVIRONMENT
   A. Non-Living Components
   B. Living Components
   C. Ecological Interrelationships
   D. Aesthetics
   E. Human Interest Values

3. ANALYSIS OF THE PROPOSED ACTION AND ALTERNATIVES
   A. Unmitigated Impacts
   B. Possible Mitigating Measures
   C. Adverse Impacts that Cannot be Avoided
   D. Relationship Between Short-Term Use and Long-Term Productivity
   E. Irreversible and Irretrievable Impacts and Commitment of Resources

4. RECOMMENDATIONS FOR THE MITIGATION OF ENVIRONMENTAL IMPACTS

5. INTENSITY OF PUBLIC INTEREST OR CONTROVERSY

6. PERSONS, GROUPS, AND GOVERNMENT AGENCIES CONSULTED

7. PARTICIPATING AGENCY STAFF

8. RECOMMENDATION WHETHER AN ENVIRONMENTAL STATEMENT SHOULD BE PREPARED

9. SIGNATURES

INSTRUCTIONS

FORMAT FOR ENVIRONMENTAL ANALYSIS RECORD

<u>Title:</u> State the name and location of the proposed action.

1. <u>DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES</u>:

   Briefly describe the proposed action, its purpose, and all reasonable alternatives for accomplishing that purpose. For the action and each alternative, identify the stages of implementation (such as construction, operation, changed level of operation, restoration or project close-out) and the discrete operations in each stage (such as blasting, excavation, operation of vehicles, reseeding, chaining) which should be analyzed for their environmental impact. Indicate the time frame of the proposed action, its location (including planning unit), its place in the MFP (if completed), and its relationship with other actions in the area.

   <u>NOTE</u>: In this section and following sections, information provided elsewhere in the case or action file need not be repeated; provide a cross-reference to other documents which contain the required information.

2. <u>DESCRIPTION OF THE EXISTING ENVIRONMENT</u>:

   A. <u>Non-Living Components</u>: Describe land, water and air quality (including soil erosion, contamination, and land uses) and manmade structures as appropriate.

   B. <u>Living Components</u>: Describe plant, animal and human populations. Environmental requirements of the species should be discussed under 2.C below.

   C. <u>Ecological Interrelationships</u>: Discuss the place of the living and non-living components above in basic ecological processes, such as the nutrient cycle, energy transfer, and the hydrologic cycle. Identify critical interrelationships, and factors influencing them, at all points in these processes. Discuss ecosystem maturity, limiting factors, and life cycles as appropriate. Identify conditions hazardous to animals and humans.

   D. <u>Aesthetics:</u> Describe aspects of the environment as experienced through the five senses.

   E. <u>Human Interest Values</u>: Identify educational and scientific values such as geological, ecological or archeological values. Identify recorded historical values, and present day cultural values including group customs and local economic factors.

321b1

3. ANALYSIS OF THE PROPOSED ACTION AND ALTERNATIVES:

For the proposed action and each alternative, including the alternative of no action, analyze the possible environmental impacts of the discrete operations identified under Item 1 above. The following format should be used:

A. Unmitigated Impacts: Discuss impacts on living and non-living components, ecological interrelationships, aesthetics, and human interest values identified under Item 2 above which may occur if no mitigating measures are taken.

B. Possible Mitigating Measures: Discuss measures to reduce impacts through location or design modifications, timing, monitoring, restoration, etc. Describe stipulations which government agencies will impost, as well as measures applicants have agreed to employ.

C. Adverse Impacts that Cannot be Avoided: Analyze the unmitigated impacts in 3.A above and possible mitigating measures in 3.B in order to identify and discuss the net residual of adverse impacts that cannot reasonably be mitigated.

D. Relationship Between Short-Term Use and Long-Term Productivity: Discuss the cumulative long-term impact of the action combined with the effects of all actions with environmental impacts similar in character, duration and scope. Short-term refers to the period of time during which the action and associated restoration take place. Long-term refers to the time period beyond the point in time when the area should have been restored.

E. Irreversible and Irretrievable Impacts and Commitment of Resources: Discuss any irrevocable impacts on or uses of resources, such as mineral extraction, massive erosion, loss of critical wildlife habitat, or destruction of historical sites.

4. RECOMMENDATIONS FOR THE MITIGATION OF ENVIRONMENTAL IMPACTS:

Recommend coordination, stipulations, timing, etc. necessary to mitigate adverse environmental impacts. These recommendations are based on the environmental analysis only; they do not represent the final decision regarding the action. The official responsible for the final management decision will consider these environmental factors and all other factors in making that decision.

5. INTENSITY OF PUBLIC INTEREST OR CONTROVERSY:

Describe the substance and intensity of anticipated public concern at the local, regional, and national levels. Identify concerned organizations and individuals as appropriate.

6. PERSONS, GROUPS, AND GOVERNMENT AGENCIES CONSULTED:

List agencies, organizations, and individuals that were consulted. Significant input or opinions may be noted.

7. PARTICIPATING AGENCY STAFF:

List names, agencies, and title, position or area of expertise.

8. RECOMMENDATION WHETHER AN ENVIRONMENTAL STATEMENT SHOULD BE PREPARED:

Make a clear statement that, based upon the recorded analysis above, preparation of an environmental statement is or is not recommended.

9. SIGNATURES:

The employee with lead responsibility for preparing the record dates and signs the record, and the responsible official (District Manager, State Director, Service Center Director, or appropriate Assistant Director for proposed actions in their respective offices) dates and concurs in the record.

At the Washington Office, State Office, and Service Center levels, if preparation of an environmental statement is recommended, or if there is a question in the minds of participating officials (for example, technical or policy questions) whether a statement is needed, forward this environmental analysis record to the Director for review. At the District Office level, if preparation of a statement is recommended, or if there is a question in the minds of participating officials whether a statement is needed, forward the record to the State Director. If the State Director concurs in the recommendation that a statement be prepared, or if there is some question in his mind whether a statement is needed, he forwards the record to the Director for review. See BLM Manual Section 1792.15 and 1792.23, soon to be released.

At all levels, if preparation of a statement is not recommended, this record should be placed with the case or action file, and need not be forwarded to the Director unless called for.

321b3

ENVIRONMENTAL ANALYSIS CHECKLIST

Instructions

1. The headings at the top of the right hand columns will correspond to the stages of implementation and discrete operations (for the proposed action and all alternatives in turn) which were identified in Item 1 of the format.

2. The checklist items in the left hand column will provide a basis for describing the existing environment as required under Item 2 in the format.

3. Use of the right hand columns should systematically identify (for the proposed action and all alternatives in turn) possible environmental impacts that warrant discussion in the narrative under Item 3 in the format. The narrative should discuss the importance, magnitude, trends, quantification, etc. of the impact. Also describe any cumulative effects that may occur from several stages or combinations of impacts.

   A. For each heading at the top of the right hand columns, place a slash at the intersection with each checklist item in the left hand column if an impact is possible. Place an X if it is unknown whether or not there is an impact.

   B. In those boxes where there is a slash place a number 1, 2 or 3 below the line to indicate a low, moderate or high impact respectively. Above the slash place a + where the impact is beneficial to the environment. Impacts rated 2 or 3 should be discussed in the narrative.

STAGES OF IMPLEMENTATION (fill in)→								
DISCRETE OPERATIONS (fill in)→								
COMPONENTS OF THE ENVIRONMENT								
I. NON-LIVING COMPONENTS								
A. LAND								
Soil Erosion								
Chemical Soil Pollution								
Compatibility of Land Uses								
Manmade Structures								
All Other Uses								
B. WATER								
Water Supply								
Nutrients								
Chemicals and Toxic Substances								
pH								
Sediment Load								
Temperature								
Dissolved Solids								
Turbidity								
Radiological Contaminants								
Solid Debris								
Dissolved Oxygen								
Fecal Coliforms								
Algal Blooms								
C. AIR								
Carbon Monoxide								
Hydrocarbons								
Particulate Matter								
Photochemical Oxidants								
Sulfur Oxides								
Radiological Contaminants								
Wind Patterns								
II. LIVING COMPONENTS								
A. PLANTS								
Grass								
Forbs								
Brush and Shrubs								
Conifers								
Pinyon-juniper								
Broadleaf Trees								
Flowers								

B. ANIMALS

Mammals
Birds
Fish
Reptiles
Amphibians
Invertebrates

C. HUMANS

III. ECOLOGICAL INTERRELATIONSHIPS

A. ECOLOGICAL PROCESSES

Nutrient Cycle
Energy Transfer
Hydrologic Cycle

B. HAZARDS TO HUMAN AND ANIMAL HEALTH AND SAFETY

IV. AESTHETICS

A. VISUAL

Setting or Arrangement
Color

B. SOUND

Volume
Tone
Beat

C. ODOR

Pleasantness
Strength

D. TASTE OR TOUCH

E. MOOD ATMOSPHERE

Isolation
Awe-Inspiration

321b6

V. <u>HUMAN INTEREST VALUES</u>								
A. EDUCATIONAL/SCIENTIFIC								
Geological								
Ecological								
Archeological								
Hydrological (e.g. geysers)								
B. HISTORICAL								
Related to:								
Persons								
Events								
Cultures								
Architecture & Styles								
Western Frontier								
C. CULTURAL								
Related to:								
Indians								
Religious Groups								
Ethnic Groups								
D. OTHER HUMAN INTEREST VALUES								
Uniqueness								

321b7

EXHIBIT 2

OIL AND GAS LEASE - SURFACE DISTURBANCE STIPULATIONS

1. Notwithstanding any provision of this lease to the contrary, any drilling, construction or other operation on the leased lands that will disturb the surface thereof or otherwise affect the environment (hereinafter called "surface disturbing operation") conducted by lessee shall be subject, as set forth in this stipulation, to the prior approval of such operation by the Area Oil and Gas Supervisor in consultation with the appropriate surface management agency and to such reasonable conditions, not inconsistent with the purposes for which this lease is issued, as the Supervisor may require to protect the surface of the leased lands and the environment.

2. Prior to entry upon the land or the disturbance of the surface thereof for drilling or other purposes, the lessee shall submit for approval two copies of a map and explanation of the nature of the anticipated activity and surface disturbance to the Area Oil and Gas Supervisor, and will also furnish the appropriate surface management agency with a copy of such map and explanation.

An environmental analysis will be made by the Geological Survey in consultation with the appropriate surface management agency for the purpose of insuring proper protection of the surface, the natural resources, the environment, existing improvements, and for assuring timely reclamation of disturbed lands.

3. Upon completion of said environmental analysis, the Area Oil and Gas Supervisor shall notify lessee of the conditions, if any, to which the proposed surface disturbing operations will be subject.

Said conditions may relate to any of the following:

(a) The location of drilling or other exploratory or development operations or the manner in which they are to be conducted;

(b) The types of vehicles that may be used and the areas in which they may be used; and

(c) The manner or location in which improvements such as roads, buildings, pipelines or other improvements are to be constructed.

Signed this ______________________ day of ____________________, 19____

____
Lessee's Signature